BMP
Retrofit
Pilot Program

FINAL RESUBMITTAL
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June 15, 2000 (Revised)

BASIS OF DESIGN REPORT DRAINAGE DESIGN, DISTRICT 7 PS&E

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ACRONYMS

BMP	Best Management Practice
Caltrans	California Department of Transportation
PS&E	Plans, Specifications and Estimates

1.0 INTRODUCTION

1.1 General

This report documents the appropriate design elements employed in the design of an Infiltration Basin Best Management Practice (BMP) Retrofit Facility within Caltrans District 7. The type of BMP and its respective location is presented in Table 1-1. The overall purpose of the BMP Pilot Retrofit Studies is to evaluate the removal efficiency for constituents of concern, technical feasibility, and costs of retrofitting Caltrans facilities with BMPs. The content of this report will be confined to documenting the hydrologic characteristics, water quality design parameters and the hydraulic factors considered during the design phase of the program.

TABLE 1-1
PS&E Package BMP Site

SITE NO.	BMP TYPE	BMP LOCATION
1	Infiltration Basin	Northbound I-605 / Westbound SR-91 Cloverleaf Connector

1.2 Objectives

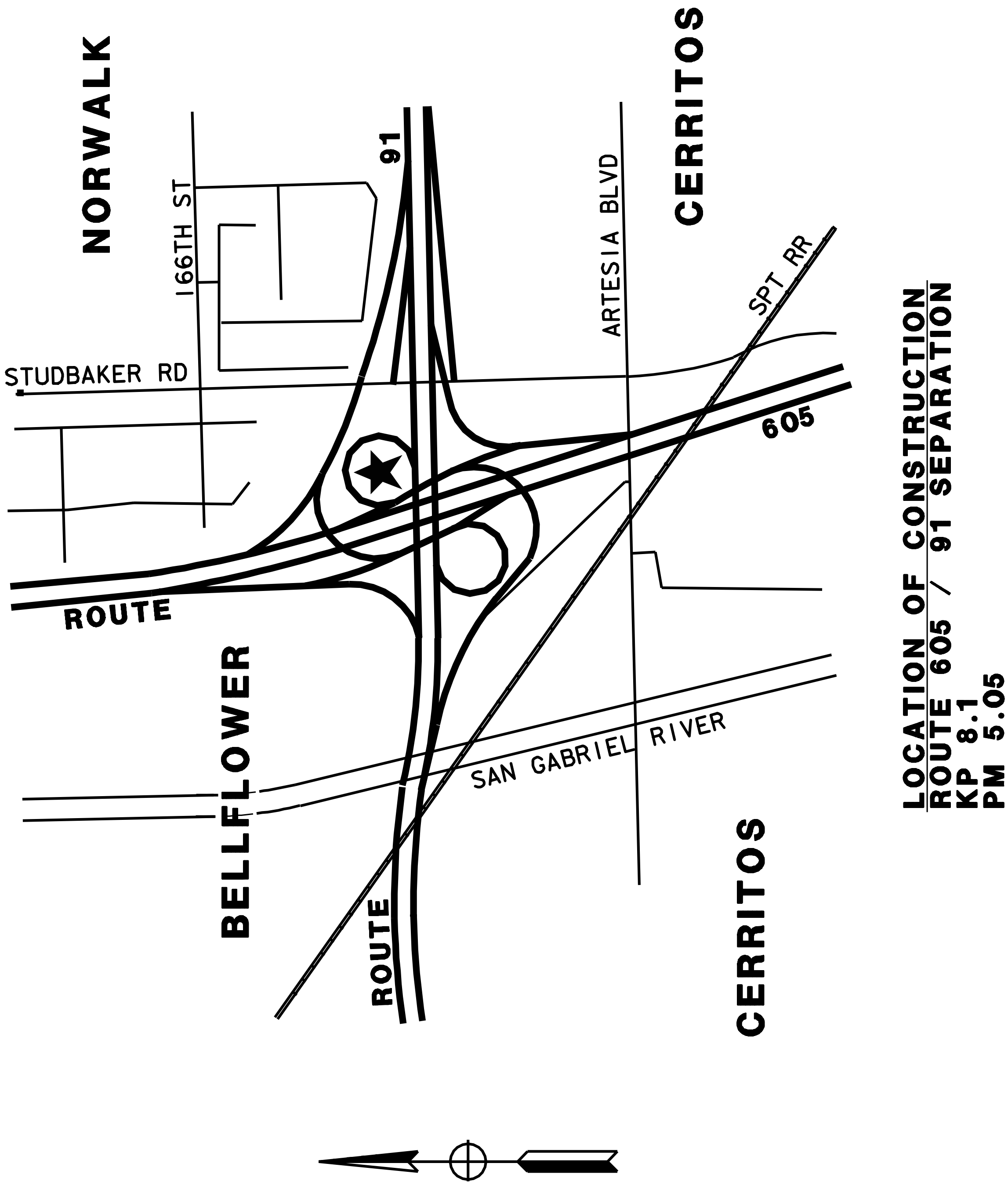
The objective of the design of the BMP Retrofit Pilot Facilities was to follow, as close as possible, the design guidelines provided in the *Scoping Study, Retrofit Pilot Program, Caltrans District 7* prepared by Robert Bein, William Frost and Associates dated April 28, 1998, while complying with applicable Caltrans District 7 site-specific requirements. Deviations from these design guidelines will be noted in Section 3 of this report.

1.3 Project Location

The location of the BMP Retrofit Facility within Los Angeles County is presented in Figure 1-1. This location is the same as that proposed in the *BMP Retrofit Pilot Program Composite Siting Study, District 7* prepared by Robert Bein, William Frost and Associates dated January 30/April 9, 1998. No deviation from the Siting Study was necessary.

1.4 Construction Cost

The preliminary engineer's estimated cost of construction for the Infiltration Basin BMP is $537,257. This estimate is based on quantity of work items extracted from the design, and current Caltrans cost data (*1996 Contract Cost Data, Revision No. 1, 8/97*). A copy of the Engineer's Estimate is provided in Appendix E, Engineering Cost Estimate.



BMP LOCATION
FIGURE 1-1

2.0 HYDROLOGIC CHARACTERISTICS

One of the first and most important steps prior to hydraulic design of a BMP facility is estimating the discharge rate or volume of runoff that the BMP will be required to convey, control, and treat. To effectively design the BMPs, peak discharge rates and/or total rainfall volumes for design storm events were calculated. In accordance with study guidelines, one-year and 25-year design storm events were used to design the BMPs. In the specific case of the infiltration basin, another important hydrologic process considered in the design was the infiltration of surface water to the soil. Understanding native soil conditions and infiltration rates provided necessary information in the sizing of this BMP.

The following sections describe in detail the approach used in estimating the peak discharge rates and total rainfall volumes, and the sources of hydrologic data used in the analysis.

2.1 Rainfall Characteristics (Parameters)

Rainfall characteristics utilized in the design include:

- Intensity (rate of rainfall),
- Duration (time rainfall lasts), and
- Frequency (statistical probability of how often rainfall will occur).

Sources of rainfall data include the Caltrans Average Intensity Duration Curves for District 7; staff at the Los Angeles County Department of Public Works (LACDPW); and the *Scoping Study, Retrofit Pilot Program, Caltrans District 7,* prepared by Robert Bein, William Frost and Associates dated April 28, 1998.

The amount of rainfall from a 1 year, 24 hour storm was estimated by Brown and Caldwell using rain gauge stations within the study area (Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, May 1997). Rainfall values were determined using precipitation records from 1944 to 1995 (24-hour rainfall totals) from the Los Angeles International Airport (LAX) weather station. The data was analyzed using the log-Pearson type III method and by the annual series data method. Also, a second and third set of rainfall records were analyzed from the Van Nuys and the downtown Los Angeles weather stations. Both locations were used to compare with the information gathered from LAX because all of the stations are located in the same rainfall region (coastal plain) as defined by the Los Angeles Department of Public Works (LACDPW).

At the LAX weather station, the calculated 1 year, 24 hour rainfall equaled 0.5-inches (log-Pearson) and 1.12-inches (annual series data method). Two extreme drought years may have influenced the outcome of the log-Pearson analysis. The Van Nuys and downtown Los

Angeles stations were 0.71 and 0.73-inches, respectively, using the annual series data method. From the results, the exact size of the 1 year, 24 hour storm event is uncertain. The study concluded that 1 inch of rainfall is slightly greater than what the log-Pearson method estimates, and slightly less than what the annual series method estimates. It was therefore determined that 1.0 inches was a reasonable value for the Los Angeles Coastal Plain (Caltrans Zone K, see Appendix A Hydrology Calculations), and was used to design and size each BMP.

For the 25 year storm event, the standard Caltrans average intensity duration curves were utilized. The BMP site is located in the Los Angeles Coastal Plain (Region K) rainfall zone. Refer to Appendix A, Hydrology Calculations for further information. Using the pre-determined zone and the Caltrans District 7 average intensity duration curve for a 25 year storm event, the desired rainfall intensity was computed.

2.2 Soil Types and Infiltration

An infiltration basin requires permeable soils or subsoils to function properly. A minimum infiltration rate of 1.94×10^{-4} cm/s is required, which corresponds to sand, loamy sand, sandy loam, and silt loam soil groups. Based on the *Composite Siting Study, District 7* prepared by Robert Bein, William Frost and Associates dated January 30/April 29, 1998, the permeability rate was found to be 1.6×10^{-6} meters per second. Although the permeability rate is considered marginal, the site was chosen because of its exceptional space and access characteristics.

The *Pre-Construction Geotechnical Evaluation Report* prepared by The L.K.R. Group, Inc., dated 9 March 1998, indicates that borings drilled at the site encountered sandy material from about 0.9 to 3.0 meters. From the surface to about 0.9 meters and from 3.0 to 9.1 meters, the material was sandy silt to clayey silt.

2.3 Methodology and Procedure

The estimation of the peak discharge (Q_{peak}) for a recurrence interval of a 1-year and 25-year storm event was calculated using the Rational Method, which computes the discharge as follows:

$$Q_{peak} = 0.28CiA$$

Where:

Q_{peak} = Design discharge in m^3/s
C = Coefficient of runoff

i = Average rainfall intensity in mm/hr for the selected frequency and for the duration equal to the time of concentration (t_c)
A = Drainage area in km^2

The average rainfall intensity (i) is a function of the time of concentration (t_c), and the rainfall zone in which the BMP is located. The time of concentration is defined as the time required for storm runoff to travel from the most remote point of the drainage basin to the point of interest. As given in the Caltrans Highway Design Manual, time of concentrations were calculated using the following equation:

$$t_c = \frac{3.3(1.1 - C)(L)^{1/2}}{[S(100)]^{1/3}}$$

Where:

t_c = time of concentration in minutes
C = Coefficient of runoff
L = Overland travel distance in meters
S = Slope in m/m

Table 2-1 presents the hydrologic parameters and the corresponding time of concentration for the 1-year storm event.

TABLE 2-1
TIME OF CONCENTRATIONS, 1-YEAR

Tributary Area Designation	Tributary Area (m^2)	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)
A	1,760	0.90	1	110	6.9
B	2,008	0.95	2	290	6.7
C	6,844	0.40	10	150	13.1
D	3,725	0.90	1	90	6.3
E	2,680	- -	- -	0	0
Weighted Ave.	***17,017***	***0.68***			***9.5***

As presented in the above table, the average time of concentration was calculated to be below the Caltrans Highway Design Manual minimum of 10 minutes. Therefore, 10 minutes was used to compute the rainfall intensity. The resulting 1-year peak discharge rate for the BMP is presented in Table 2-2.

TABLE 2-2
PEAK DISCHARGE RATES, 1-YEAR

Total Trib. Area (m^2)	Ave. Runoff Coefficient C	Rainfall Intensity (i) (in/hr)	Q_{peak} (m^3/s)
17,017	0.68	0.32[1]	0.026

[1] Rainfall intensity provided by the Los Angeles County Department of Public Works for a 1-year storm event with a t_c = 10 minutes.

2.4 Summary of Results

Table 2-3 summarizes the expected peak discharges for the 1-year and 25-year storm events, the average 1-year 24-hour design storm event rainfall total the permeability rates and soil types.

TABLE 2-3
SUMMARY OF HYDROLOGIC DATA

Design Event	Q_{peak} (m^3/s)	Ave. 1-Year 24-Hour Storm Event Rainfall Total (in)	Permeability Rate (cm/s)	Soil Type
25	0.256	---	1.6×10^{-4}	0.0 to 0.9 meters: sandy silt to clayey silt
1	---	1.0	---	0.9 to 3.0 meters: sandy material
				3.0 to 9.1 meters: sandy silt to clayey silt

3.0 WATER QUALITY DESIGN DISCUSSION AND ASSUMPTIONS

Technical references used for BMP water quality design include the *Caltrans Highway Design Manual* (Caltrans 1997), *the Caltrans Storm Water Quality Handbook, Planning and Design Staff Guide* (Caltrans 1997), *Evaluation and Management of Highway Runoff Water Quality* (U.S. Dept. of Transportation FHWA, 1996), *Composite Siting Study, District 7* (Robert Bein, William Frost and Associates 1998), and *Scoping Study, Retrofit Pilot Program, Caltrans District 7* (Robert Bein, William Frost and Associates 1998).

The tributary drainage area map is located in Appendix C, Hydrology Maps.

3.1 Site 1, I-605 / SR-91 Separation (Infiltration Basin)

The location of the infiltration basin was determined by the *Composite Siting Study*. This site consists of four drain inlets collecting runoff from mainline freeway, the cloverleaf connector ramp and a Caltrans maintenance station.

3.1.1 Design Summary

The BMP retrofit pilot is an off-line infiltration basin. The site location for the infiltration basin is a cloverleaf interior of the Northbound I-605 / Westbound SR-91 separator. The majority of the runoff is conveyed to the southern portion of the cloverleaf interior. The area is slightly sloped from north to south. The basin's placement within the cloverleaf was based on Caltrans safety zone construction clearance requirements.

The *Composite Siting Study* states that the drainage system consists of one culvert and one curb drain which is approximately six acres of tributary drainage area. However, the drainage area from these two runoff points is actually three and half (3.5) acres. The total tributary drainage from the four drain inlet plus the cloverleaf interior is approximately five and one-third (5.33) acres. The basin will capture 79% of the total tributary area.

Of the four tributary inlets draining to the cloverleaf area, flows from two are diverted to the infiltration basin. Runoff from the I-605 Northbound and from the overside drain from Westbound SR-91 will not be directed to the basin. The flow from the Northbound I-605 would only be 6% of the total runoff volume, and was therefore excluded from the design. The Westbound SR-91 would be 15% of the total runoff volume. The downdrain is located along the southern slope of the cloverleaf, approximately 20 meters away from the existing outlet. To convey the runoff from the Westbound SR-91, the flow path would have to avoid crossing the natural drainage path to the existing outlet. In order to get this flow to the basin, it would have to be diverted to the outlet of the maintenance station. This would required a diversion junction box from the existing 300 mm CMP, piping and another inlet junction box to the maintenance station outlet. Combining this flow to the maintenance station increases the runoff volume and could surcharge the maintenance station. This was avoided because the maintenance station has flooded in the past. However, Section 3.1.2 does provide an analysis of the costs to treat this additional runoff for future reference.

The two other points of runoff, from the maintenance station and cloverleaf ramp, will be discharged separately into the basin, at the east and west sides. Of the total designed runoff captured by the basin, the maintenance station portion is 72 % of the flow and the cloverleaf ramp is 12% of the flow, the remaining 16% is the direct rainfall on the basin. The maintenance station drain to the cloverleaf collects flow from Westbound I-91, the maintenance station and maintenance station surrounding embankment. The runoff will be diverted to the infiltration basin through a 600 mm plastic pipe at a 1% slope. The existing headwall will be removed and replaced by a Caltrans standard G2 inlet. The G2 structure will be modified to allow excessive runoff to overflow to a two (2.0) meter wide concrete swale to the existing outlet. The cloverleaf connector runoff flows through a G1 inlet and 300 mm plastic pipe at a slope of 2% to infiltration basin. Each inlet will be provided with energy dissipators to prevent scouring and provide pretreatment and uniform flow by spreading and distributing the runoff over the basin floor. The G2 Inlet is designed with a sump, and will therefore also act as a Forebay, providing pretreatment and sediment removal upstream of the Infiltration Basin.

The basin floor will be flat and the embankment will be sloped at 1:3. During construction, compaction of the basin will be avoided if possible by excavating from the sides. The contract documents include guidelines for minimizing compaction during construction. Vegetation (seed mix) will be established on the basin floor and side slopes to improve infiltration and trap constituents. Also, the surrounding area affected by construction will be supplemented with seed mix to reduce erosion potential as required by the specifications. The suggested seed mix for the infiltration basin and the surrounding graded area was recommended by RBF’s Design Directive No. 6 (see Appendix D Hydroseed Mix Recommendations).

The basin has been design to collect the 1 year, 24 hour storm runoff volume, and store larger storm events. This is accomplished by using the available freeboard of 0.6 meters and by the design of the maintenance yard two-way directional flow with an overflow orifice to control the volume detained in the basin. As the storm intensity declines, the basin depth will decrease to the invert overflow elevation of the pipe, leaving a surface water depth in the basin of 0.22 meters. The overflow level is set to detain the 1 year, 24 hour storm event of 1-inch runoff volume in the infiltration basin. This design ensures flows in excess of 1 year, 24 hour storm will not affect the basin's capability to capture, detain and treat the initial runoff. Calculations for the infiltration basin are located in the Appendix A Hydrology Calculations. The basin is designed for a runoff volume of 432 cubic meters. The volume was determined by the contributing drainage area plus 1-inch of rainfall. The bottom surface area will be 1,963 square meters with a dewatering time of 38 hours.

All other storm water runoff that enters the cloverleaf will be directed by earthen or concrete swales to the outlet and not enter the infiltration basin.

Concrete pads are located at each corner to provide elevation control benchmarks. A bubbler tube to measure the basin's water depth will be anchored to a concrete pad near the center of the basin. A lysimeter will measure water quality in the vadose zone beneath the basin floor and be located in the basin near the access road.

Maintenance access is provided to the basin by a freeway pullout area, access road and ramp to the top of the embankment perimeter of the basin. The maintenance road around the basin will be approximately three (3.1) meters wide and be of asphalt concrete with a class 2 aggregate base underlay. This perimeter road is required by Caltrans for vector control, maintenance of the basin side and invert,and for mobility of vehicles. Also an access ramp from the road to the basin floor will be provided. Metal beam guard will be placed along both the shoulders of the cloverleaf ramp in accordance with District requirements.

3.1.2 Tributary Drainage Area

The infiltration basin treats runoff from a headwall along the western side of the cloverleaf, a headwall at the southeast corner of the cloverleaf, and from rain falling directly on the surface of the basin. The western headwall transports runoff from the Northbound I-605 / Westbound SR-91 connector road which surrounds the basin, and has a tributary area of 2,008 square meters. The southeast headwall transports runoff from three separate sources outside of the cloverleaf; the Cerritos Maintenance Station, a 100 meter long section of the Westbound lanes of Route SR-91 (which is being treated by a Biofiltration Swale - see Report CTSW-RT-98-55, Basis of Design Report, Drainage Design, District 7 Procurement A), and three roadway embankments to the north, south, and west of the maintenance station (the east side of the station faces Studebaker Road). The tributary areas of these three sources are 3,725 square meters, 1,760 square meters, and 6,844 square meters, respectively. The final source of runoff is the basin itself, which has a tributary area of 2,680 square meters. The total tributary area from these five sources is 17,017 square meters. The total 1 year, 24 hour peak flow for this site is 0.026 cubic meters per second (0.9 cfs).

As described in the previous paragraph, the cloverleaf connector receives runoff from seven separate areas, four of which (with a combined tributary area of 17,017 m^2) are captured in the infiltration basin. The three remaining areas that are diverted around the infiltration basin have a combined tributary area of approximately 4,300 m^2 . The infiltration basin could be enlarged to include the retention of this additional runoff, and still satisfy the design criteria. The additional areas are presented in Table 3-1.

TABLE 3-1
AREAS UNTREATED BY BMP

Area ID	Area (m^2)	Description
1	1,800	Two drain inlets along the (E)SR-91/(N)I-605 Connector Road which collect runoff from an 80-m section of the (E)SR-91/(N)I-605 Connector Road and a 20-m section of (N)I-605.
2	1,900	One drain inlet along the (N)I-605/(W)SR-91 Connector Road which collected runoff from a 60-m section of the (N)I-605/(W)SR-91 Connector Road and a 75-m section of (W)SR-91.
3	600	An overside drain along the (N)I-605/(W)SR-91 Connector Road which collects runoff from an 80-m section of the (N)I-605/(W)SR-91 Connector Road, including the Infiltration Basin maintenance pullout.

The infiltration basin is designed such that the Area 1 runoff is conveyed directly to the outlet pipe via an earth swale; the Area 2 runoff discharges into the concrete overflow swale; and the Area 3 runoff follows the existing grade toward the outlet pipe. Each of these areas could be diverted to the infiltration basin using the following approach:

- Area 1. The headwall could be replaced with a drain inlet, and a 300-mm plastic pipe could transport the runoff to the basin, with a flared end section and an energy dissipater located at the discharge point. The section of pipe under the perimeter road would be encased in concrete.

- Area 2. The headwall could be replaced with a drain inlet, and a 300-mm plastic pipe could transport the runoff to the basin, with a flared end section and an energy dissipater located at the discharge point. The section of pipe crossing the overflow swale would need to be elevated above the overflow swale. The pipe under the perimeter road would be encased in concrete .

- Area 3. The overside drain was replaced with a drain inlet as part of the original design. A 50-m section of 300-mm plastic pipe could transport the runoff to the new drain inlet proposed for Area 1, and then to the basin in the same pipe as the Area 1 runoff.

The diversion of the additional 4,300 m^2 of tributary area results in retention of an additional 109 m^3 of runoff in the infiltration basin (using the design storm criterion of 1 in. of runoff). Assuming that the depth of the basin remains constant, this volume would require that the west end of the basin be moved to the west approximately 11.4 m.

The cost to redirect the additional three tributary areas to the infiltration basin would be approximately $21,000. A detailed cost estimate is provided in Table 3-2.

TABLE 3-2
ADDITIONAL COST TO TREAT UNTREATED AREAS

Item	Description	Qty	Unit	Unit $	Cost
1	Remove Headwall	2	EA	$2,000.00	$4,000
2	Class 2 Aggregate Base	7.8	M3	$70.00	$546
3	Asphalt Concrete (Type B)	8.9	TONN	$69.27	$616
4	Minor Concrete (Minor Structure)	5	M3	$300.00	$1,500
5	Minor Concrete (Pipe Encasement)	4	M3	$500.00	$2,000
6	300mm Plastic Pipe	105	M	$100.00	$10,500
7	300mm Corrugated Steel Pipe	(10)	M	$200.00	($2,000)
8	300mm Steel Flared End Section	(1)	EA	$750.00	($750)
9	300mm Plastic Flared End Section	2	EA	$500.00	$1,000
10	RSP (Backing No. 2, Method B)	4	M3	$400.00	$1,600
11	Rock Slope Protection Fabric	9	M2	$70.00	$630
12	Miscellaneous Iron and Steel	296	KG	$4.00	$1,184
	Total Cost				**$20,826**

The above cost assumes the following:

- The additional flow is redirected to the infiltration basin as described above.
- The work is performed during the construction of the infiltration basin (to avoid additional mobilization and traffic control expenses).
- The contract unit prices for the infiltration basin construction apply to this additional work.

3.1.3 Siting Contraints

Given this site is located within a cloverleaf ramp, access to the area is limited. The only way to provide safe access is from the Northbound I-605 / Westbound SR-91 connector. At the entrance to the cloverleaf ramp, a pullout area will be constructed. The area will be approximately 37 meters long by 3.5 meters wide of asphalt concrete. An existing overside drain in the pullout area will be relocated. To replace the drain, a G1 inlet, new piping and a flared end section will be constructed. To provide personnel an easy passage way to the basin a paved access road extends from the freeway pullout to the infiltration basin.

The tributary area within the cloverleaf but outside the basin can not be treated because of the District maintenance requirement for an access road surrounding the basin.

Electricity can not be obtained from freeway electrical wiring, and there are no nearby power sources. Therefore, power for the bubblers will be provided by batteries.

4.0 HYDRAULIC ANALYSIS

4.1 Design Criteria

This section will address the hydraulic performance of the BMP Retrofit Pilot Facility The critical runoff event frequency designated in the *Caltrans Highway Design Manual* (Caltrans 1997) is for a storm with a return period of 25 years. Therefore, the runoff from a 25 year storm event was used for the critical event in checking the capacity of the BMP Retrofit Facility. Other technical references used include the *Caltrans Storm Water Quality Handbook, Planning and Design Staff Guide* (Caltrans *1997)* and the *Scoping Study, Retrofit Pilot Program , Caltrans District 7 (*Robert Bein, et al. April 28, 1998*).*

4.2 Methodology and Design Procedures

Runoff into the infiltration basin was calculated using the rational method, following the same procedures as those presented in Section 2 for the 1 year event. The only difference in the calculation for the two recurrence intervals is the coefficient of runoff, C. As explained in the Caltrans Highway Design Manual, infiltration, detention, and other losses have a proportionally smaller effect during less frequent, higher intensity storms. As given in the manual, the effect was accounted for by multiplying the runoff coefficient by a frequency factor of 1.1. The resulting product was then used, unless the product was greater than 1.0, in which case a value of 1.0 was used. The time of concentrations are presented in Table 4-1.

TABLE 4-1
TIME OF CONCENTRATIONS, 25-YEAR

Tributary Area Designation	Tributary Area (m^2)	Runoff Coeff. C	Slope (%)	Overland Travel Distance (m)	t_c (min)
A	1,760	0.99	1	110	3.8
B	2,008	1.00	2	290	4.5
C	6,844	0.44	10	150	12.4
D	3,725	0.99	1	90	3.4
E	2,680	- -	- -	0	0
Weighted Ave.	***17,017***	***0.74***			***6.7***

As presented in the above table, the average time of concentration was calculated to be below the Caltrans Highway Design Manual minimum of 10 minutes. Therefore, 10 minutes was used to compute the rainfall intensity. The resulting 25-year peak discharge rate for the BMP is presented in Table 4-2.

TABLE 4-2
PEAK DISCHARGE RATE, 25-YEAR

Total Trib. Area (m^2)	Ave. Runoff Coefficient C	Rainfall Intensity (i) (in/hr)	Q_{peak} (m^3/s)
17,017	0.74	2.90[2]	0.256

[2] Rainfall intensity from Caltrans District 7 Average Intensity Duration Curves for a 25-year storm event with a t_c </= 10 minutes.

Determination of water levels at various components of the infiltration basin BMP during the 1-year and 25-year storm event was performed using the US EPA's Storm Water Management Model XP-SWMM. This program is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff, which accounts for the reverse flow that will occur in one of the inlets to the infiltration basin.

The effect of the 25-year critical storm event on the infiltration basin BMP Retrofit Facility was determined with respect to the increase in runoff volume. Of particular concern was the potential of the maintenance station to flood. In general, this site provides very little head loss to accommodate adequate drainage. Storm water from the maintenance station area exits at 19.77 meters elevation to the cloverleaf. It flows to an existing outlet at 19.55 meters, allowing approximately 0.23 meters or approximately 9-inches of fall. Flooding of the Caltrans Cerritos Maintenance Station is a severe constraint on the construction of the infiltration basin at the selected site. Flooding of the maintenance station occurs at an elevation of 19.96 meters. As currently designed, the water level in the infiltration basin will reach 19.82 meters elevation during a 25 year runoff event (4-inches of rainfall). During the 25 year storm event, flow will enter the basin until it reaches the pipe overflow elevation of 19.72 meters. At which time, flow will be directed to the existing outlet through a two (2.0) meter wide concrete swale. Water will back-up in the maintenance station to an elevation of 19.86 meters.

4.3 Summary of Results

On the basis of the above information and the results of the XP-SWMM model (which are included in Appendix B), it can be concluded that the above mentioned BMP facilities will be adequate to handle the runoff from a 25 year runoff event, provided that the existing Caltrans facilities are adequate to handle the 25 year event. Minor flooding is predicted to occur on the southern edge of the parking lot of the Caltrans Cerritos Maintenance Station, but the water level will recede to an elevation lower than the parking lot in a matter of hours. We believe this will be an improvement over the current situation.

The results of the model simulation are summarized below:

Location	**Model Node Name**	**Max. Water Elevation (m)**	
		1-Year	**25-Year**
Headwall at SW corner of MS	MSOUTLET	19.81	19.94
Overflow inlet upstream of Basin	MH1	19.75	19.81
Infiltration Basin	INFILTRATN	19.51	19.76
Outlet Headwall	HEADWALL	19.65	19.76

REFERENCES

Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, prepared for the California Department of Transportation, Environmental Program, May 1997.

California Department of Transportation (Caltrans), *1996 Contract Cost Data, Revision No. 1*, August 1997.

California Department of Transportation (Caltrans), *Average Intensity Duration Curves for District 7*, Los Angeles County Department of Public Works.

California Department of Transportation (Caltrans), *Caltrans Highway Design Manual*, 1997.

California Department of Transportation (Caltrans), *Caltrans Storm Water Quality Handbook, Planning and Design Staff Guide*, 1997.

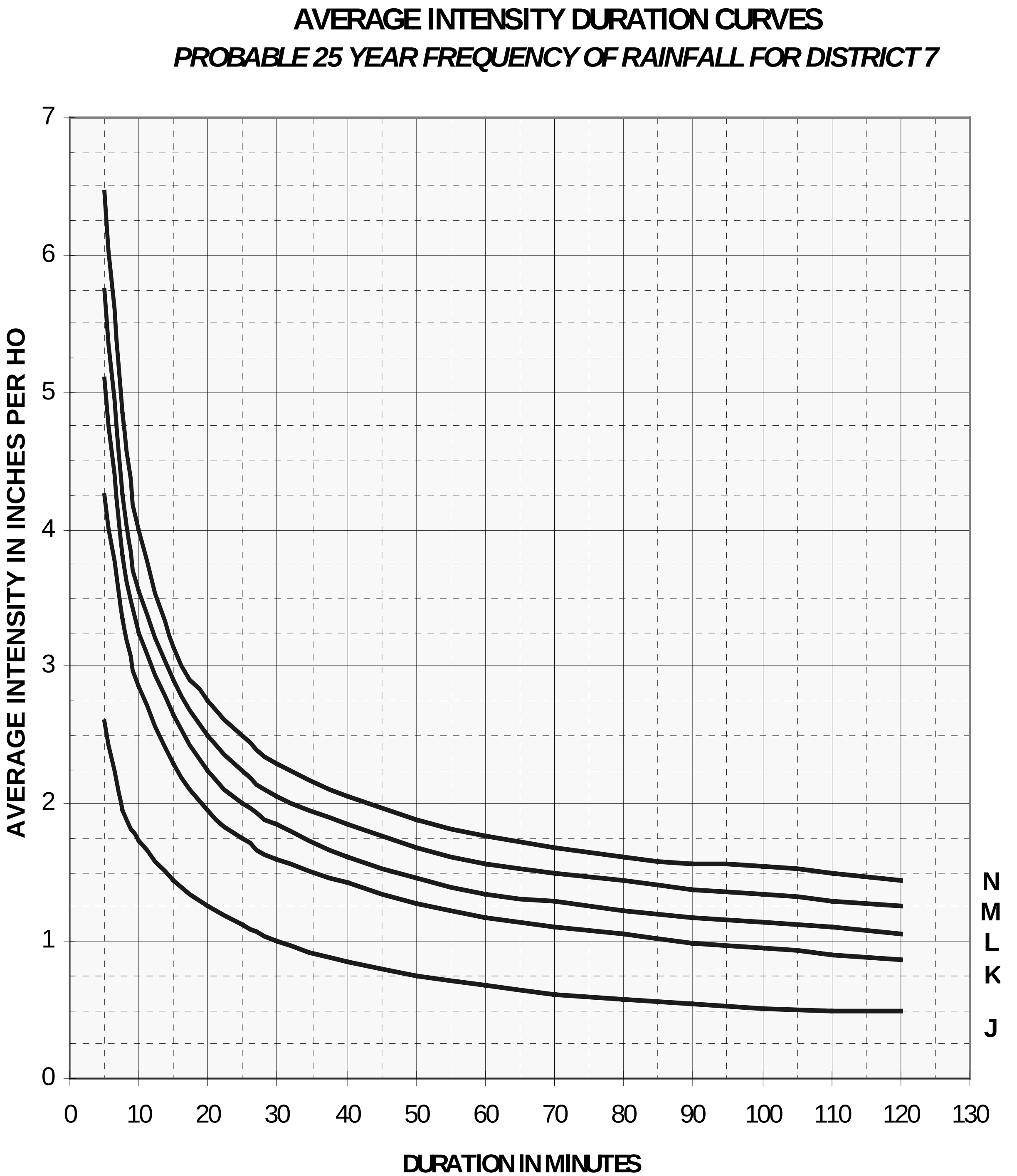
The L.K.R. Group, Inc., *Pre-Construction Geotechnical Evaluation Report, District 7,* March 9 1998.

Robert Bein, William Frost and Associates, *Scoping Study, Retrofit Pilot Program, Caltrans District 7*, prepared for the California Department of Transportation, Environmental Program, April 28, 1997.

Robert Bein, William Frost and Associates, *BMP Retrofit Pilot Program, Composite Siting Study, District 7*, prepared for the California Department of Transportation, Environmental Program, April 9, 1998.

APPENDIX A

HYDROLOGY CALCULATIONS


AVERAGE INTENSITY DURATION CURVES
PROBABLE 25 YEAR FREQUENCY OF RAINFALL FOR DISTRICT 7
AVERAGE INTENSITY IN INCHES PER HO
DURATION IN MINUTES
0
1
2
3
4
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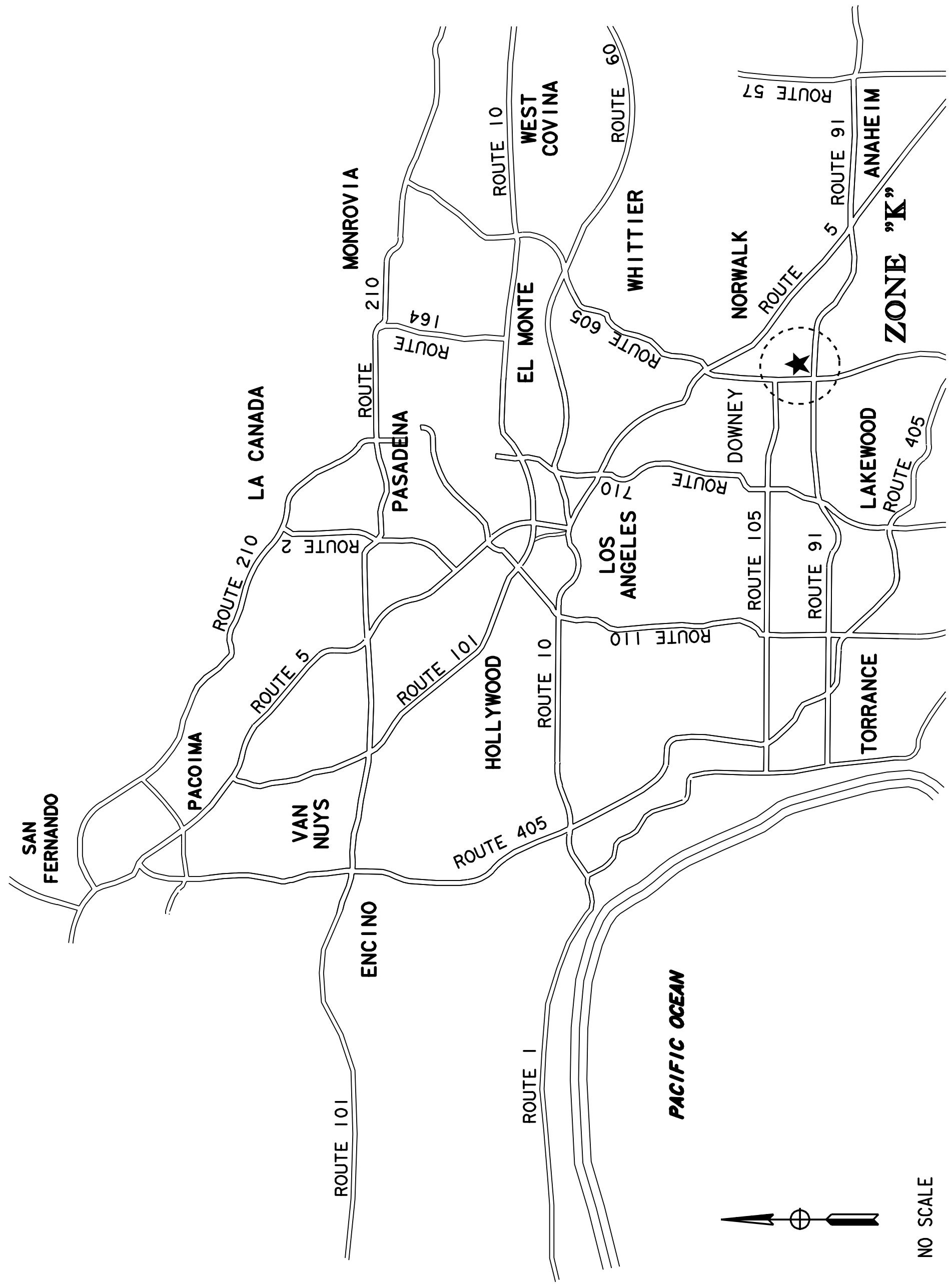


Note : Information provided by Mr. Keith Lilley, Los Angeles County Department of Public Works

BMP SITE RAINFALL ZONES

Infiltration Basin Calculations

Known: Tributary Drainage Area = 4.2 acres (17,017 sq m)
Basin Infiltration Rate = 1.6 x 10^{-6} m/s

Design: 1 year, 24 hour storm event - 1 inch (0.0254 m) of runoff

Initial Assumption: Dewatering time of 38 hours (136,800 sec)

Calculations:

Basin Volume: 17,017 sq m * 0.0254 m = 432 cubic m

Basin Depth: 136800 s * 1.6 x 10-6 m/s = 0.22 m

Basin Bottom Surface Area: 432 cubic m / 0.22 m = 1,963 sq m

Actual Dewatering Time: 432 cu. m / (1,963 sq m * 1.6 x 10-6 m/s) = 137545 s (38 hrs)

Basin Volume: 432 cubic m
Basin Depth : 0.22 m
Basin Bottom Surface Area: 1,963 sq m
Dewatering Time: 38 hours

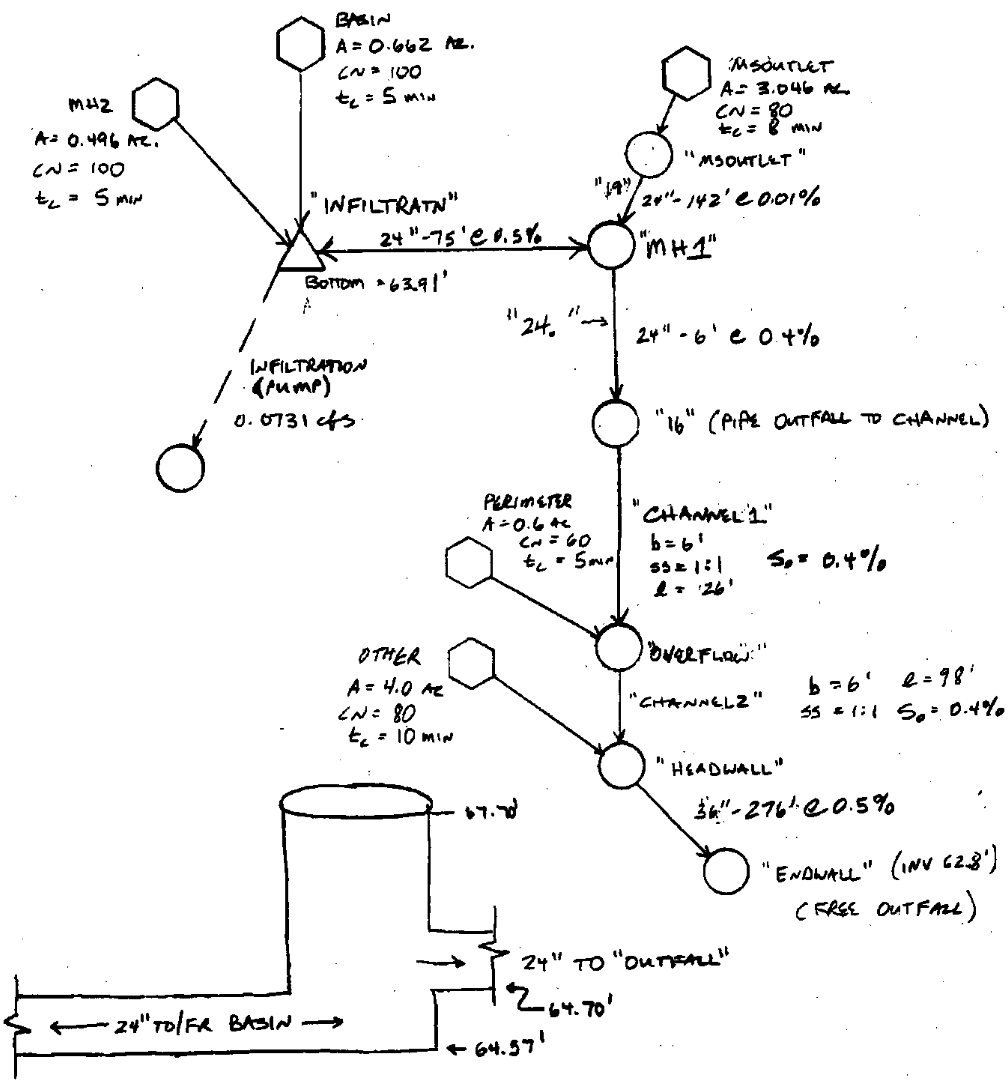
APPENDIX B

HYDRAULIC CALCULATIONS

XP-SWMM SIMULATION

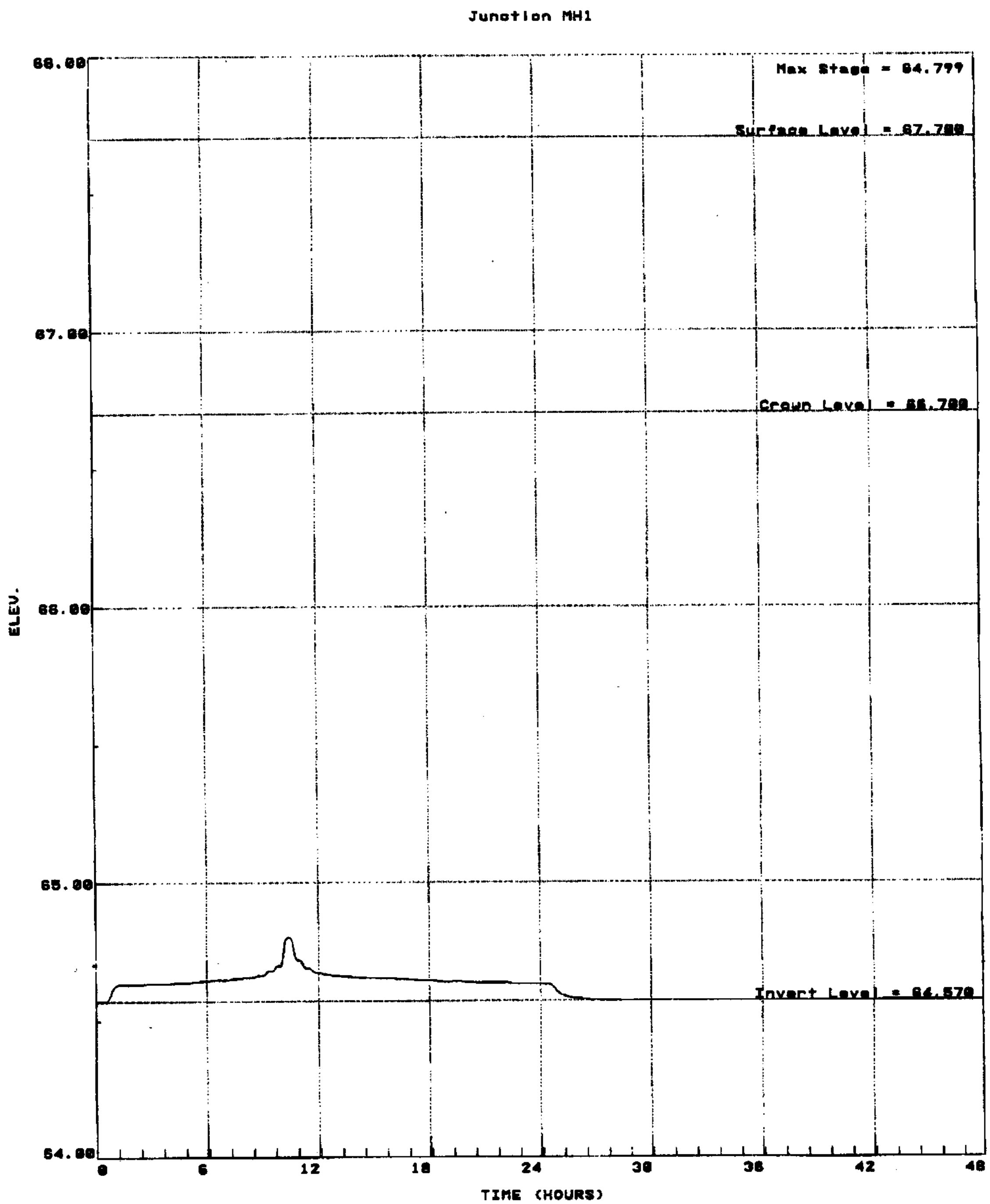
MONTGOMERY WATSON

BY DSK DATE 3/02/99 CLIENT CALTRANS SHEET 1 OF 1
CHKD. BY DESCRIPTION JOB NO.

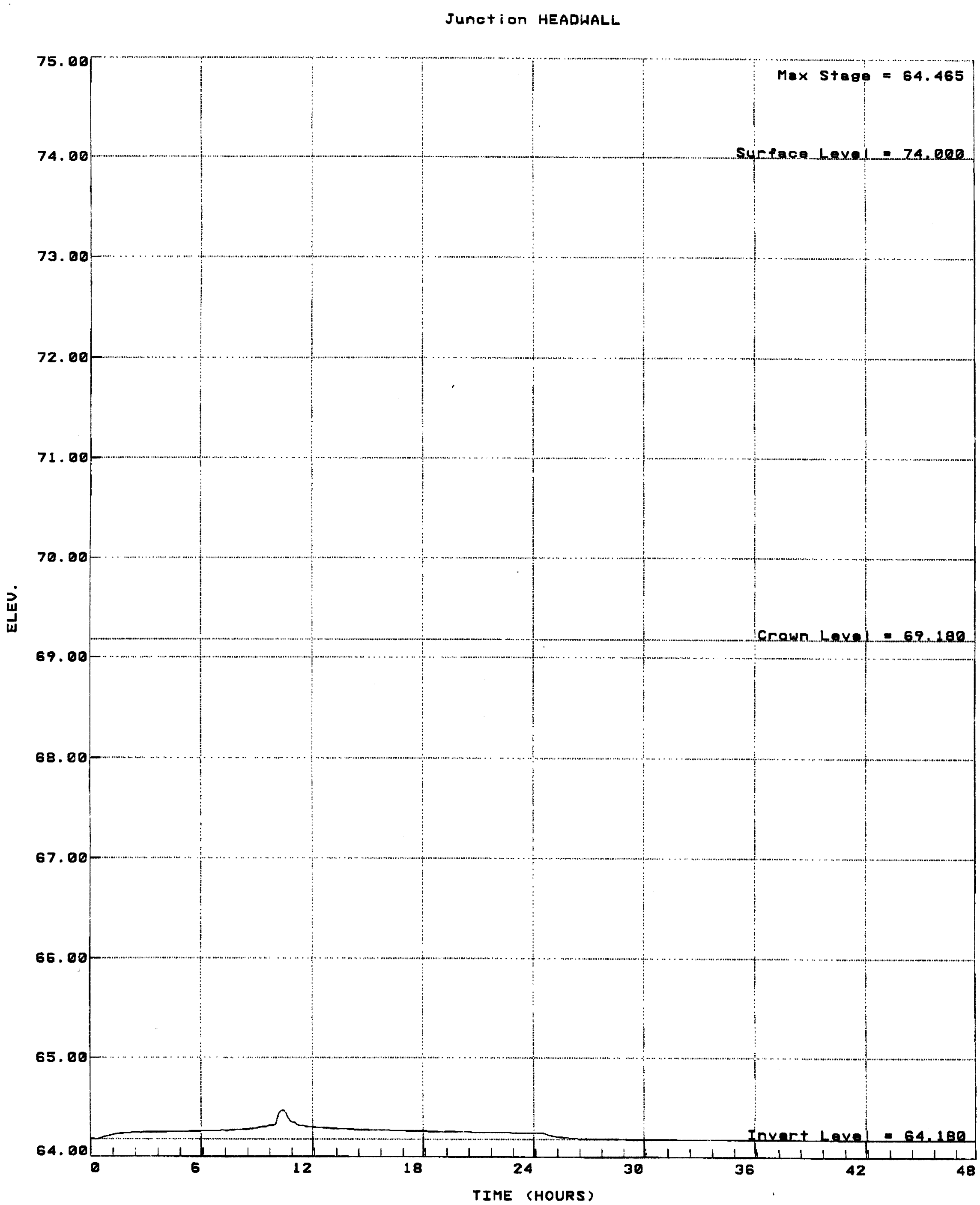


MH 1

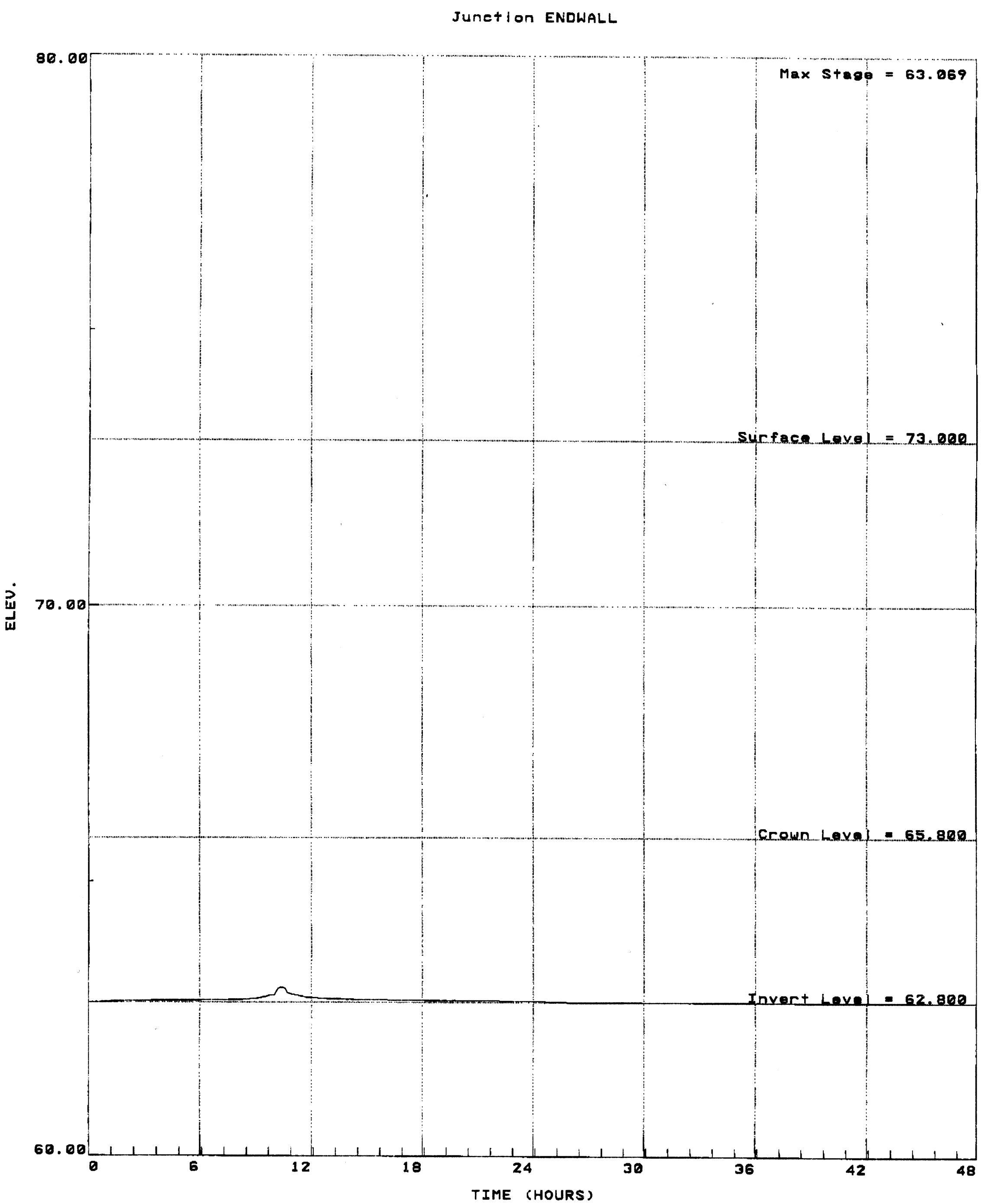
1-YEAR EVENT RESULTS


Junction MH1
Max Stage = 64.779
Surface Level = 67.700
Crown Level = 66.700
Invert Level = 64.570
68.00
67.00
66.00
65.00
64.00
ELEV.
0
6
12
18
24
30
36
42
48
TIME (HOURS)

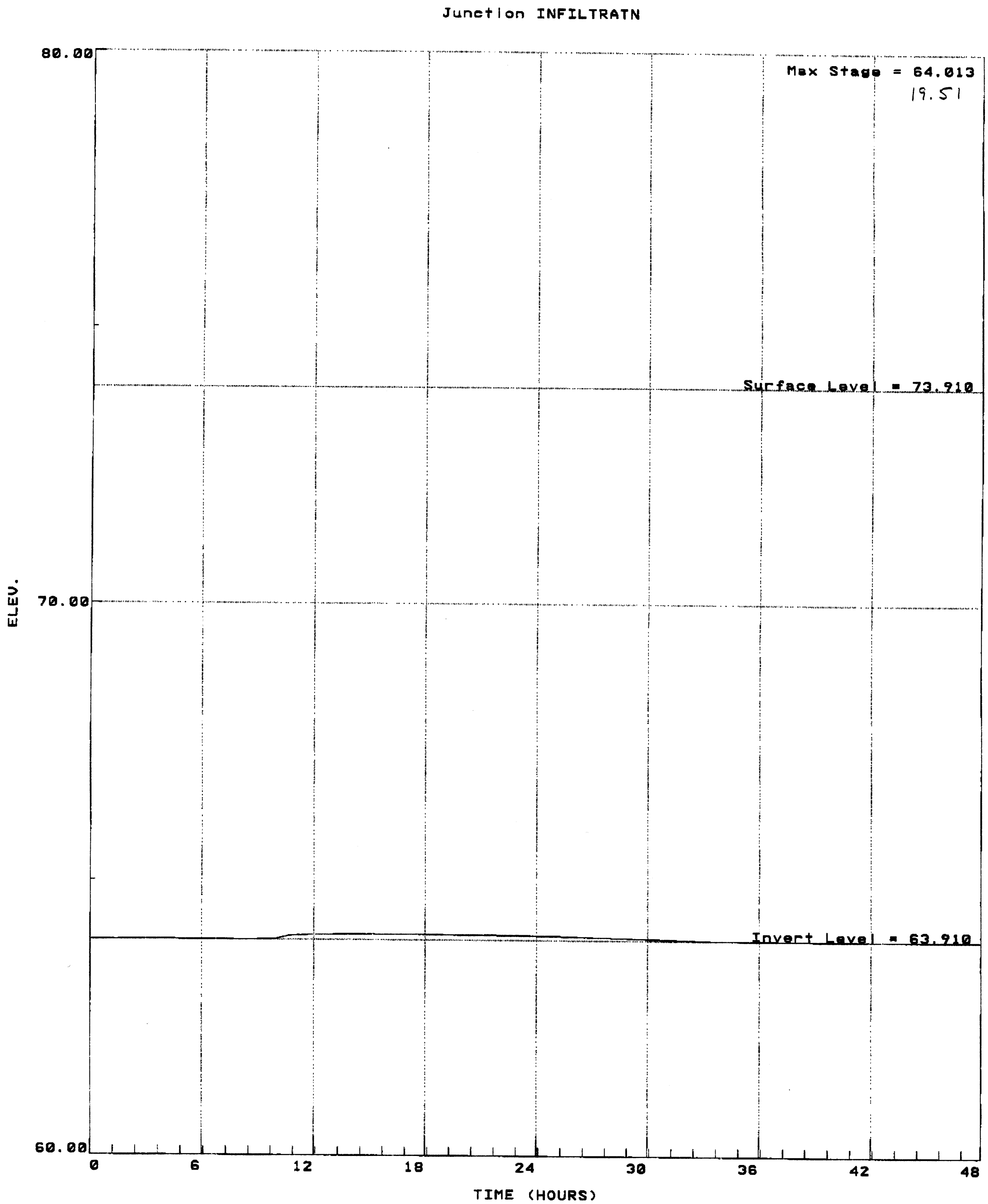
1 Year


Junction HEADWALL
Max Stage = 64.465
Surface Level = 74.000
Crown Level = 69.180
Invert Level = 64.180
75.00
74.00
73.00
72.00
71.00
70.00
69.00
68.00
67.00
66.00
65.00
64.00
ELEV.
0
6
12
18
24
30
36
42
48
TIME (HOURS)

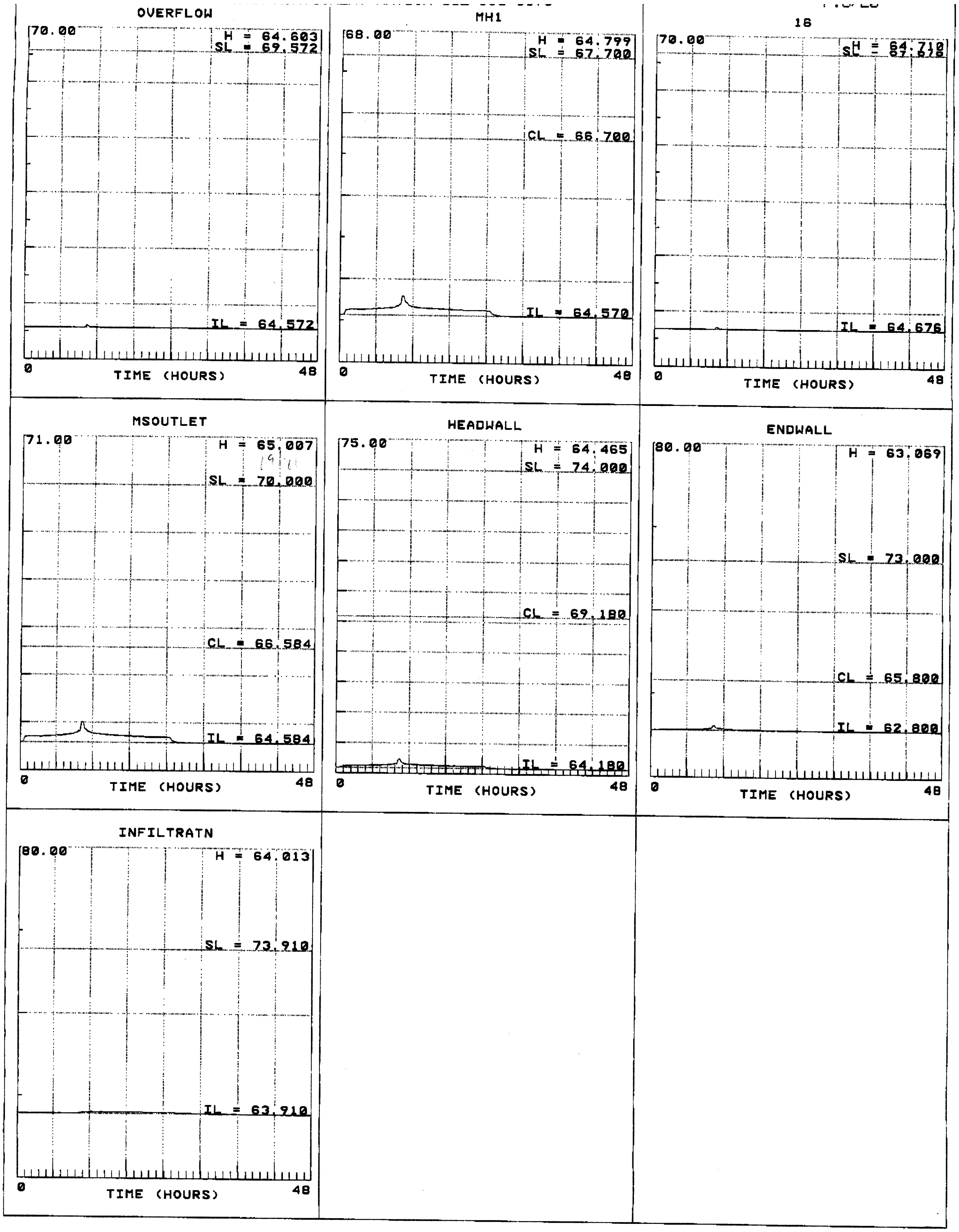
1 year


Junction ENDWALL
Max Stage = 63.069
Surface Level = 73.000
Crown Level = 65.800
Invert Level = 62.800
80.00
70.00
60.00
ELEV.
0
6
12
18
24
30
36
42
48
TIME (HOURS)

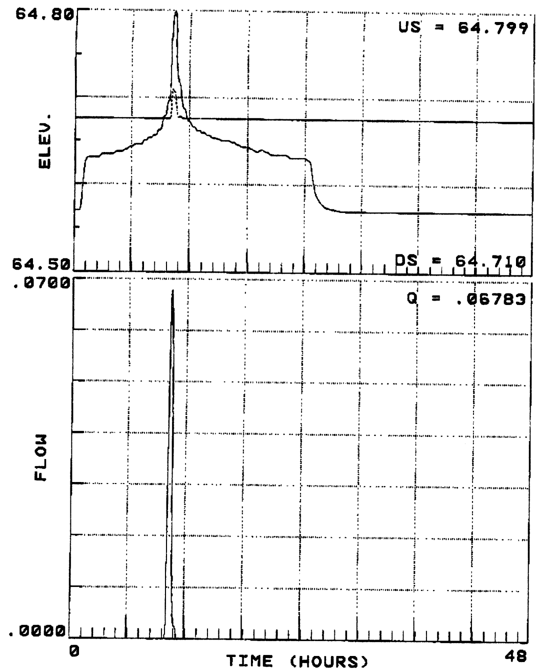
1 Year


Junction INFILTRATN
Max Stage = 64.013
19.51
Surface Level = 73.910
Invert Level = 63.910
80.00
70.00
60.00
ELEV.
0
6
12
18
24
30
36
42
48
TIME (HOURS)

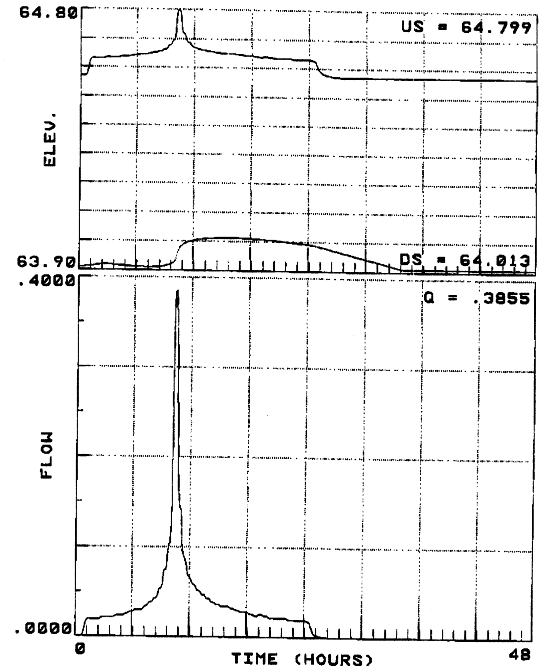
1 Year


OVERFLOW
70.00
H = 64.603
SL = 69.572
IL = 64.572
0
TIME (HOURS)
48
MH1
68.00
H = 64.799
SL = 67.700
CL = 66.700
IL = 64.570
0
TIME (HOURS)
48
16
70.00
IL = 64.676
0
TIME (HOURS)
48
MSOUTLET
71.00
H = 65.007
SL = 70.000
CL = 66.584
IL = 64.584
0
TIME (HOURS)
48
HEADWALL
75.00
H = 64.465
SL = 74.000
CL = 69.180
IL = 64.180
0
TIME (HOURS)
48
ENDWALL
80.00
H = 63.069
SL = 73.000
CL = 65.800
IL = 62.800
0
TIME (HOURS)
48
INFILTRATN
80.00
H = 64.013
SL = 73.910
IL = 63.910
0
TIME (HOURS)
48

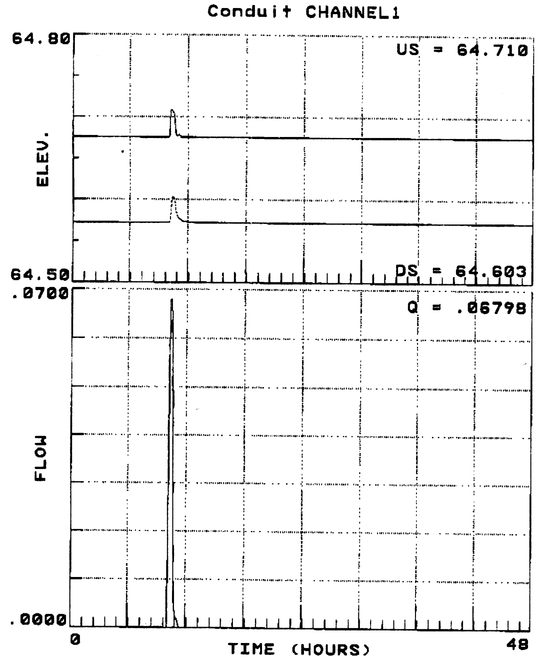
Conduit 24."



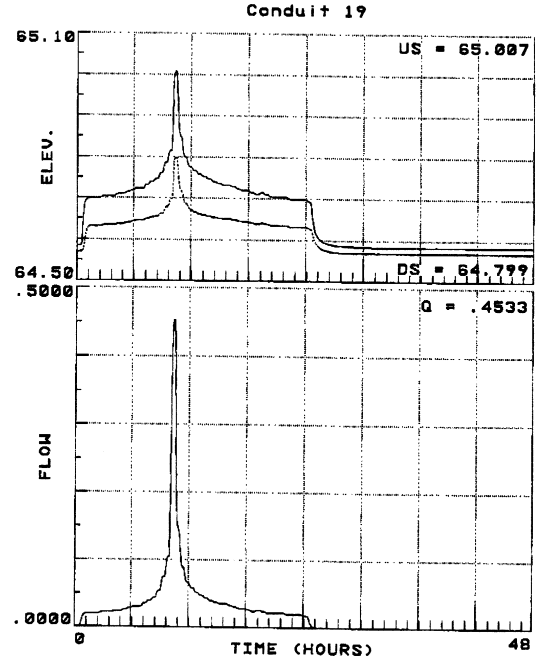
Conduit 24"

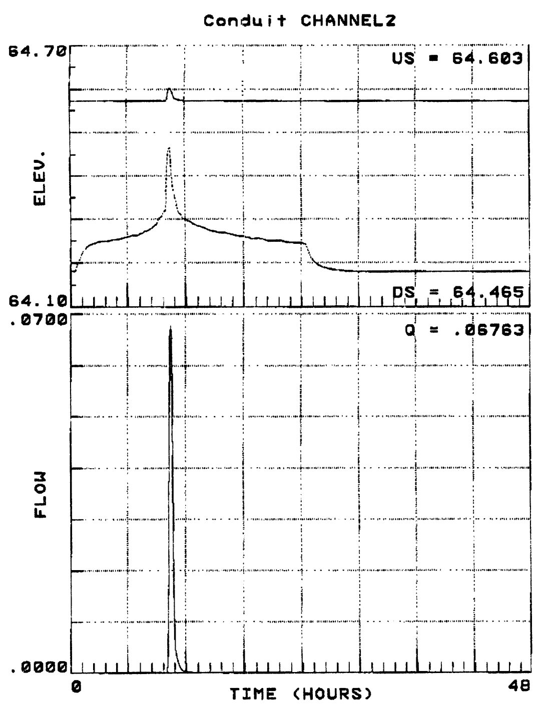


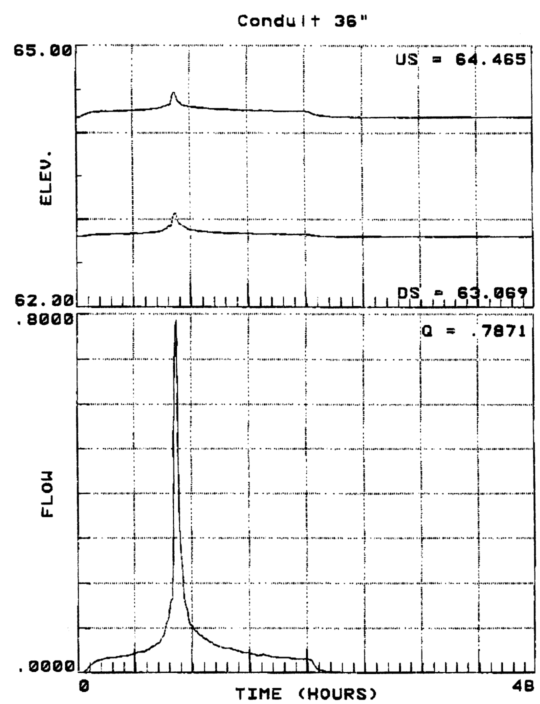
Conduit CHANNEL1



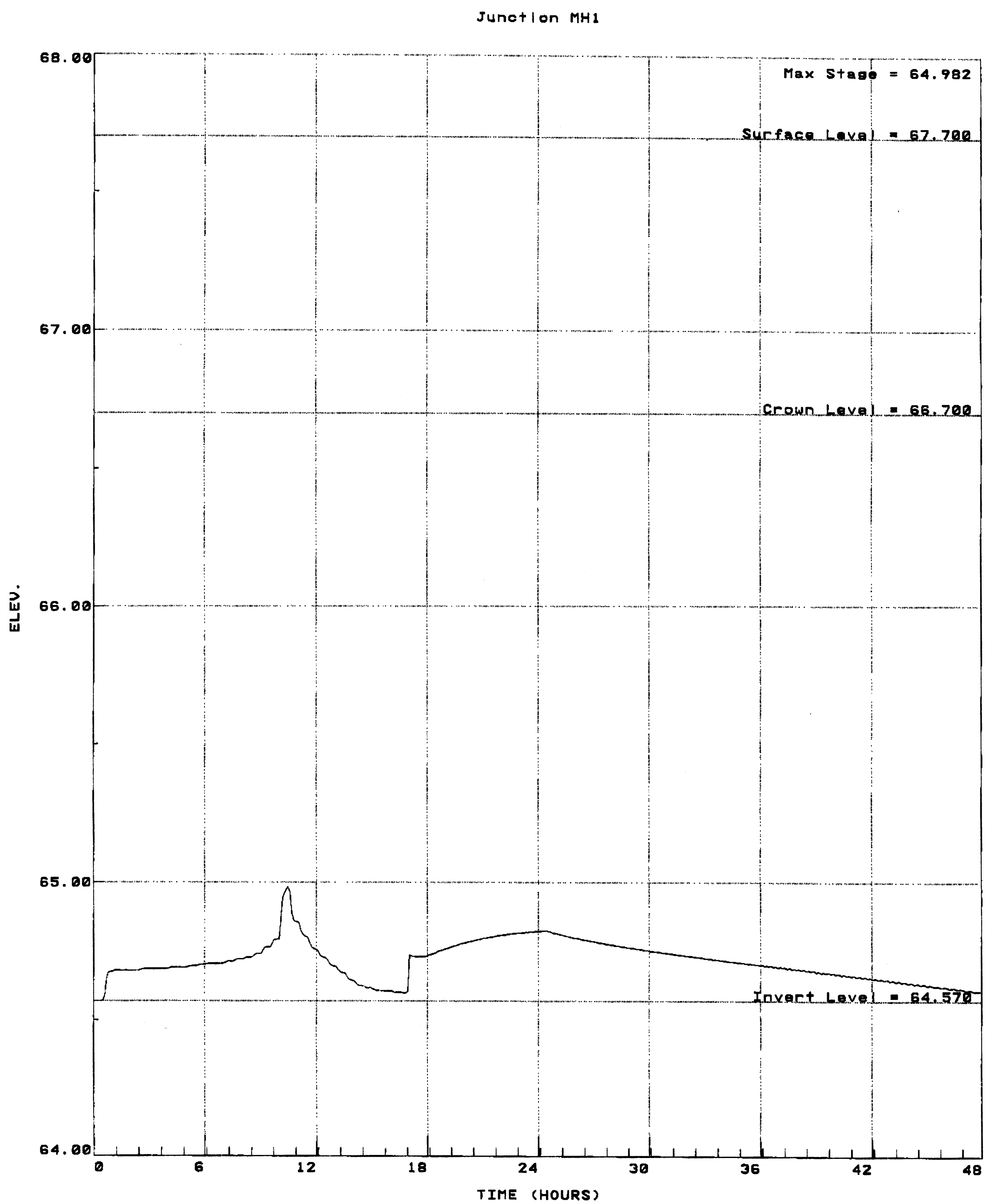
Conduit 19




Conduit CHANNEL2
64.70
US = 64.603
ELEV.
64.10
DS = 64.465
.0700
Q = .06763
FLOW
.0000
0
TIME (HOURS)
48


Conduit 36"
65.00
US = 64.465
ELEV.
62.00
DS = 63.069
.8000
Q = .7871
FLOW
.0000
0
TIME (HOURS)
48

25-YEAR EVENT RESULTS


Junction MH1
Max Stage = 64.982
Surface Level = 67.700
Crown Level = 66.700
Invert Level = 64.570
ELEV.
68.00
67.00
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65.00
64.00
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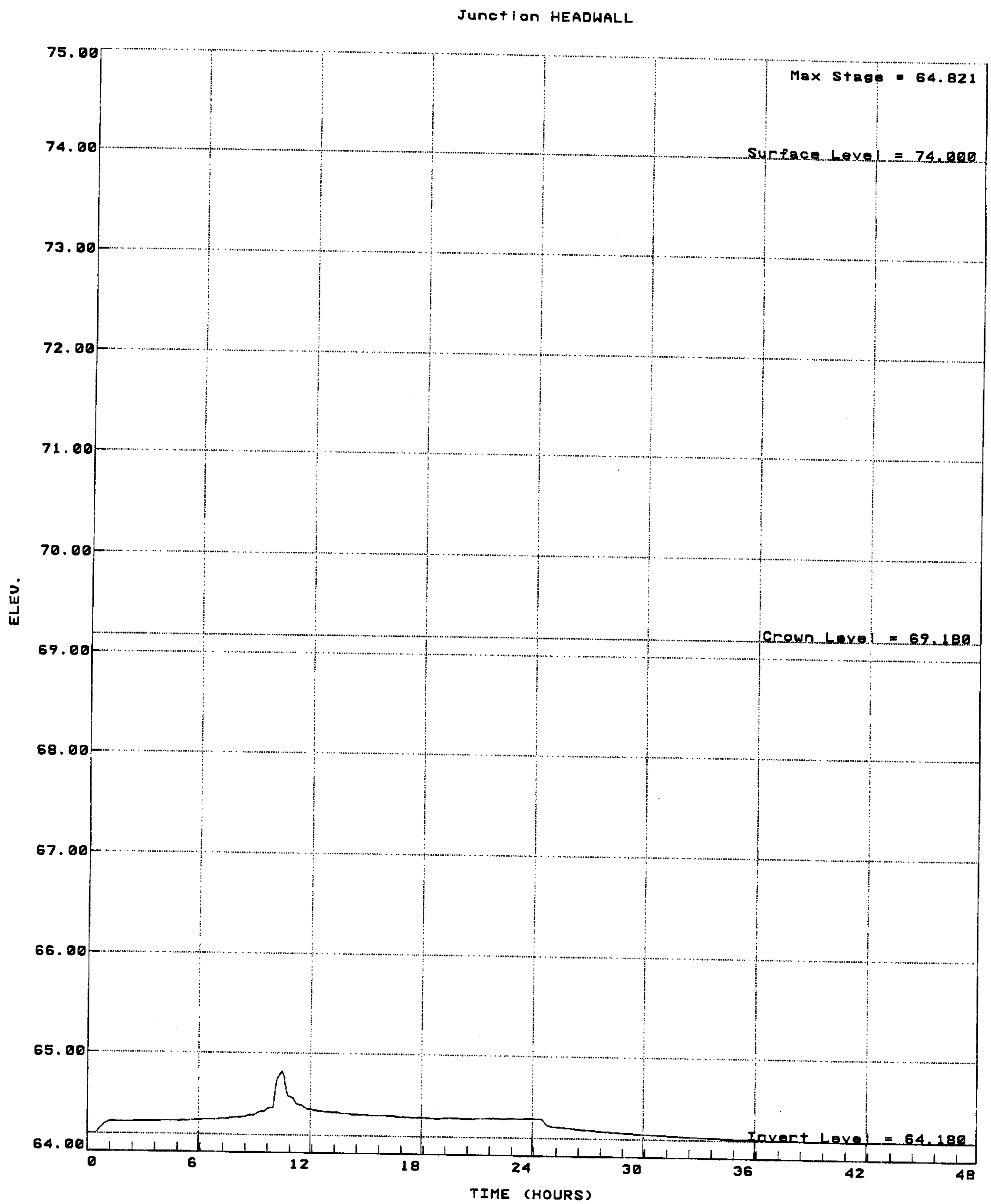
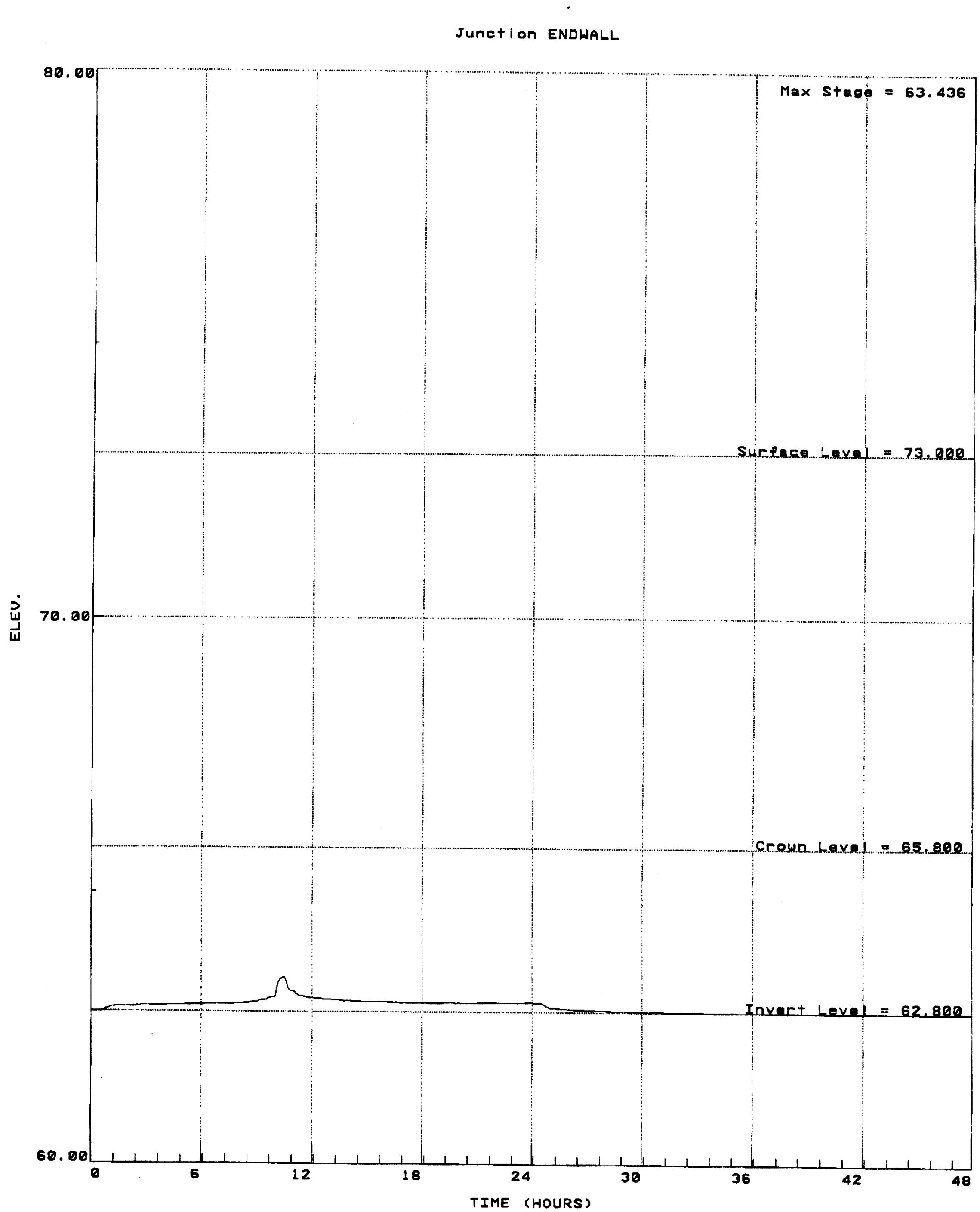
6
12
18
24
30
36
42
48
TIME (HOURS)

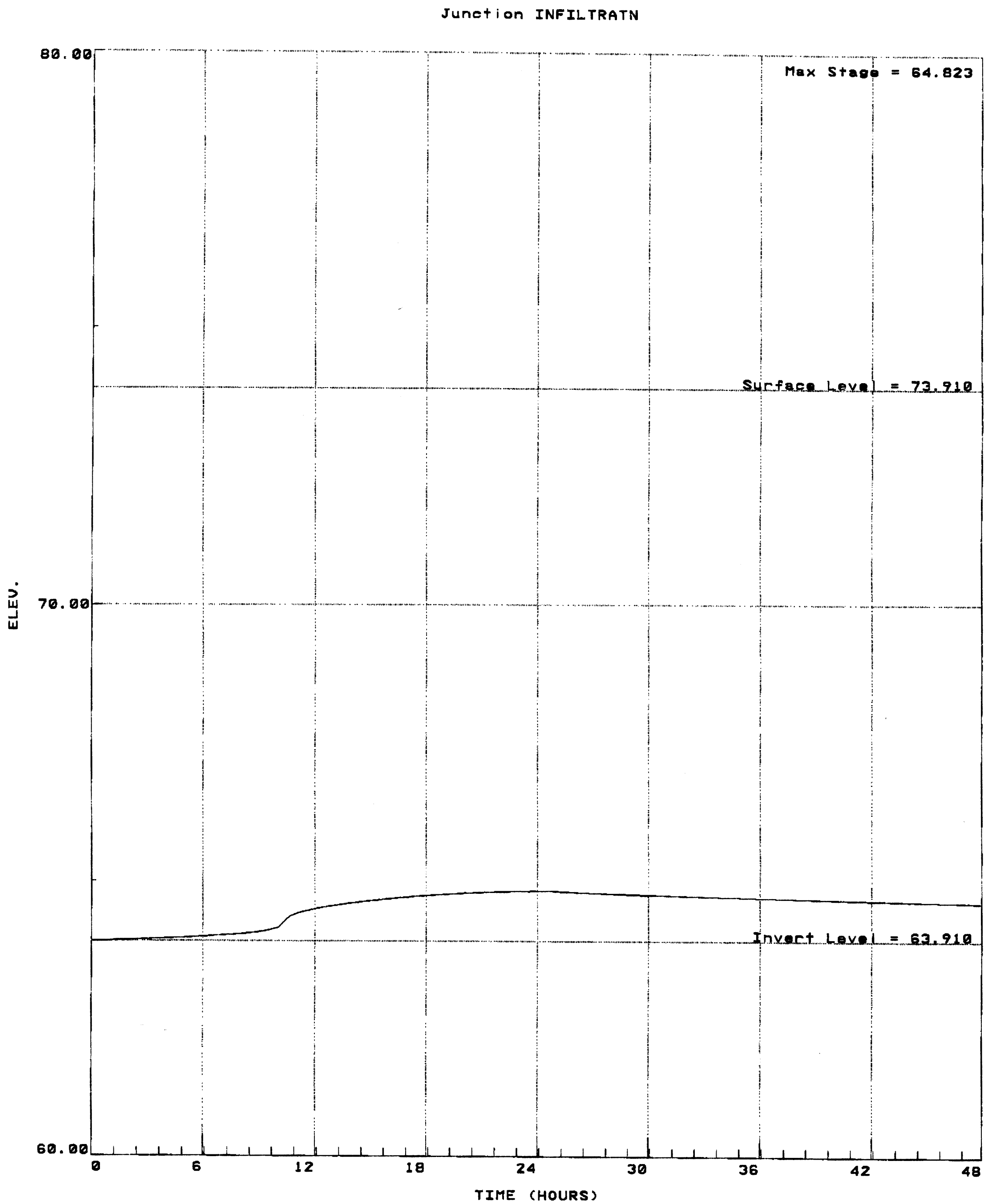
25 year


Junction HEADWALL
Max Stage = 64.821
Surface Level = 74.000
Crown Level = 69.180
Invert Level = 64.180
ELEV.
75.00
74.00
73.00
72.00
71.00
70.00
69.00
68.00
67.00
66.00
65.00
64.00
0
6
12
18
24
30
36
42
48
TIME (HOURS)

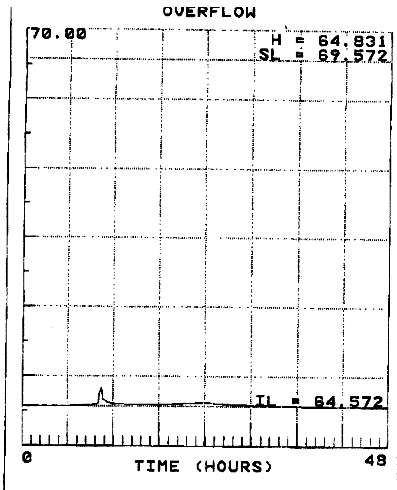
25 year

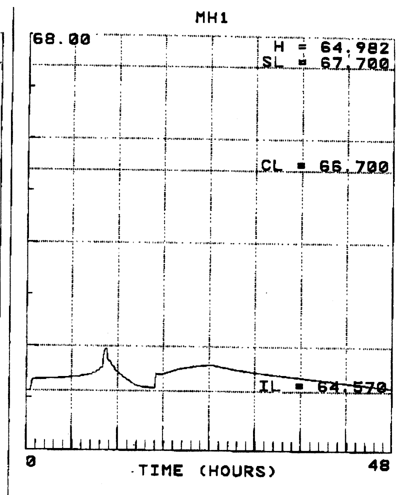

Junction ENDWALL
Max Stage = 63.436
Surface Level = 73.000
Crown Level = 65.800
Invert Level = 62.800
80.00
70.00
60.00
ELEV.
0
6
12
18
24
30
36
42
48
TIME (HOURS)

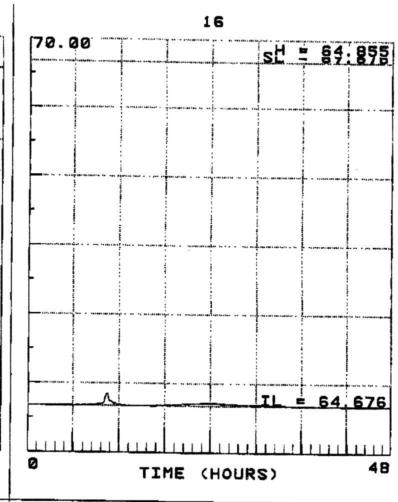
25 year

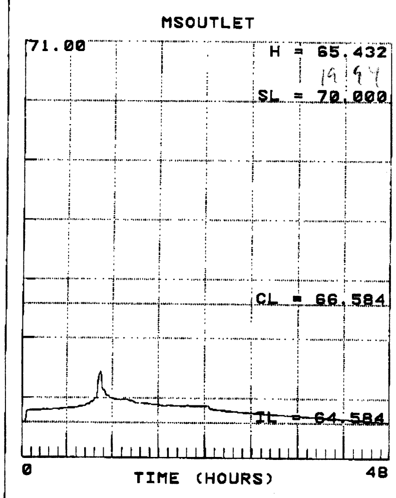

Junction INFILTRATN
Max Stage = 64.823
Surface Level = 73.910
Invert Level = 63.910
ELEV.
80.00
70.00
60.00
0
6
12
18
24
30
36
42
48
TIME (HOURS)

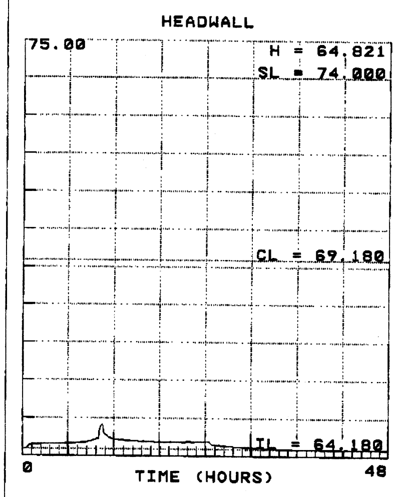
25 year

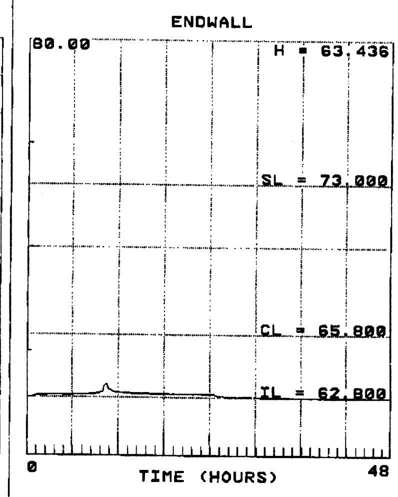

OVERFLOW
70.00
H = 64.831
SL = 69.572
IL = 64.572
0
TIME (HOURS)
48

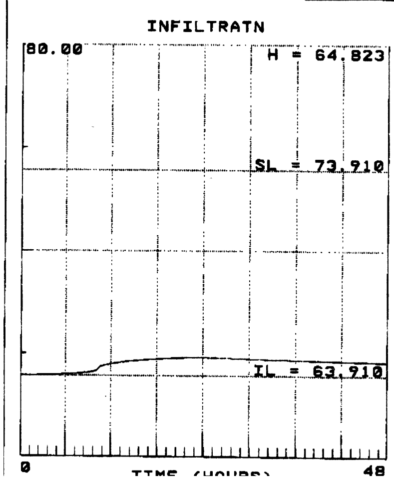

MH1
68.00
H = 64.982
SL = 67.700
CL = 66.700
IL = 64.570
0
TIME (HOURS)
48

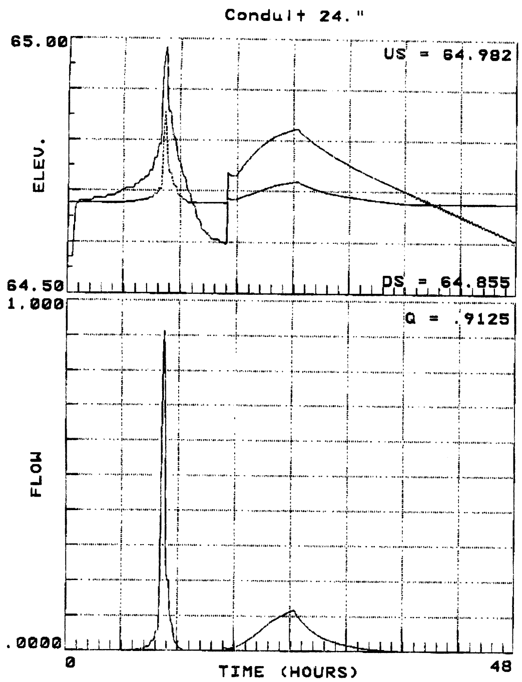

16
70.00
H = 64.855
IL = 64.676
0
TIME (HOURS)
48

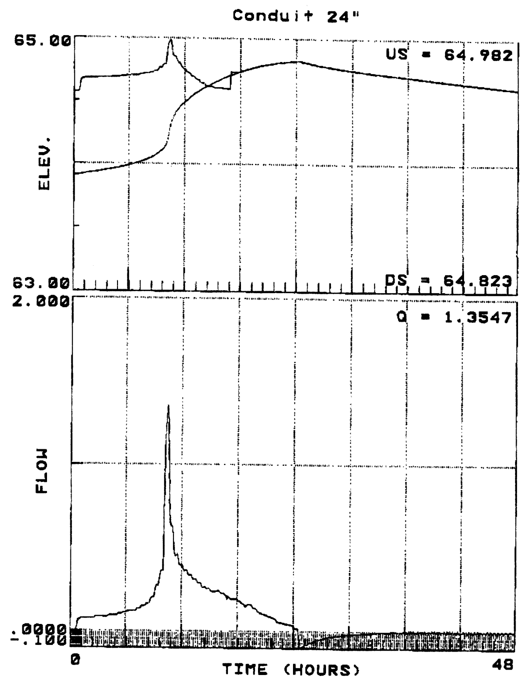

MSOUTLET
71.00
H = 65.432
SL = 70.000
CL = 66.584
IL = 64.584
0
TIME (HOURS)
48

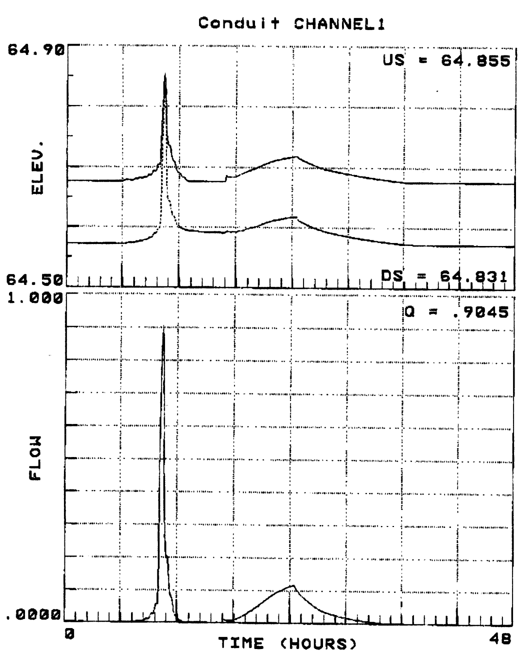

HEADWALL
75.00
H = 64.821
SL = 74.000
CL = 69.180
IL = 64.180
0
TIME (HOURS)
48

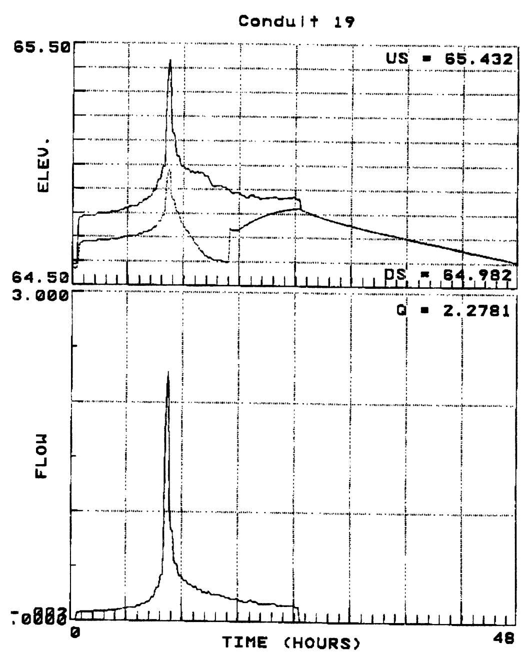

ENDWALL
80.00
H = 63.436
SL = 73.000
CL = 65.800
IL = 62.800
0
TIME (HOURS)
48

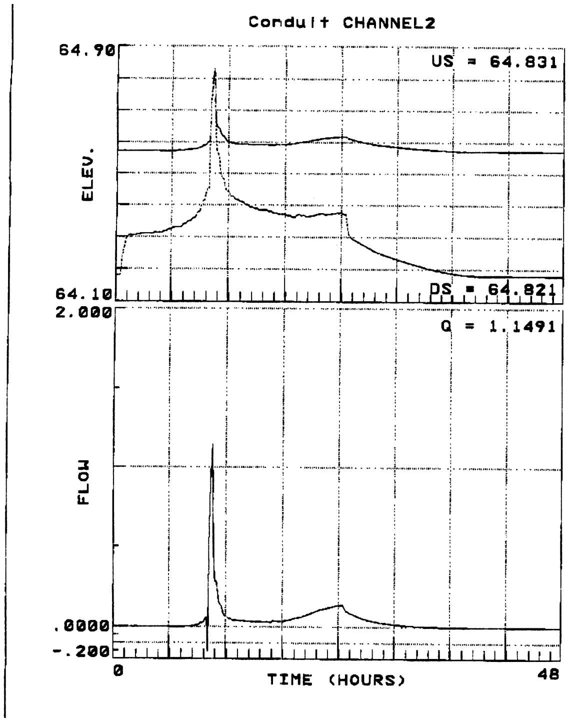

INFILTRATN
80.00
H = 64.823
SL = 73.910
IL = 63.910
0
48

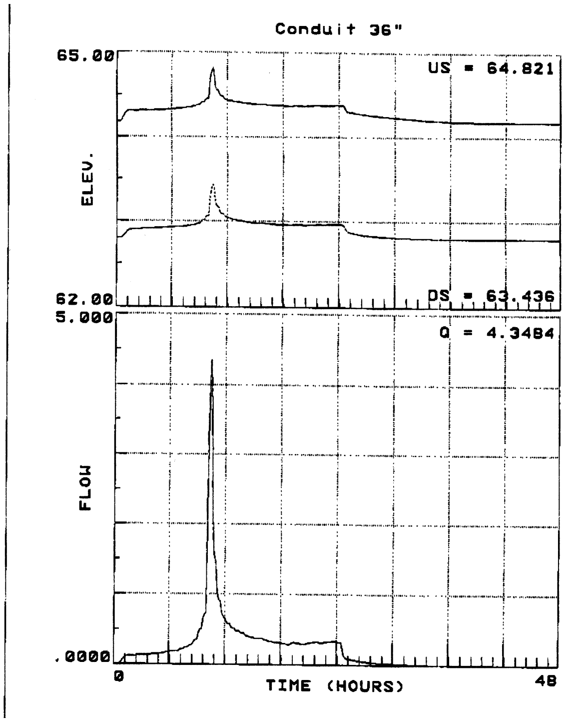

Conduit 24."
65.00
US = 64.982
ELEV.
64.50
DS = 64.855
1.000
Q = .9125
FLOW
.0000
0
TIME (HOURS)
48


Conduit 24"
65.00
US = 64.982
ELEV.
63.00
DS = 64.823
2.000
Q = 1.3547
FLOW
-.100
0
TIME (HOURS)
48


Conduit CHANNEL1
64.90
US = 64.855
ELEV.
64.50
DS = 64.831
1.000
Q = .9045
FLOW
.0000
0
TIME (HOURS)
48


Conduit 19
65.50
US = 65.432
ELEV.
64.50
DS = 64.982
3.000
Q = 2.2781
FLOW
0
TIME (HOURS)
48


Conduit CHANNEL2
64.90
US = 64.831
ELEV.
64.10
DS = 64.821
2.000
Q = 1.1491
FLOW
.0000
-.200
0
TIME (HOURS)
48


Conduit 36"
65.00
US = 64.821
ELEV.
62.00
DS = 63.436
5.000
Q = 4.3484
FLOW
.0000
0
TIME (HOURS)
48

APPENDIX C

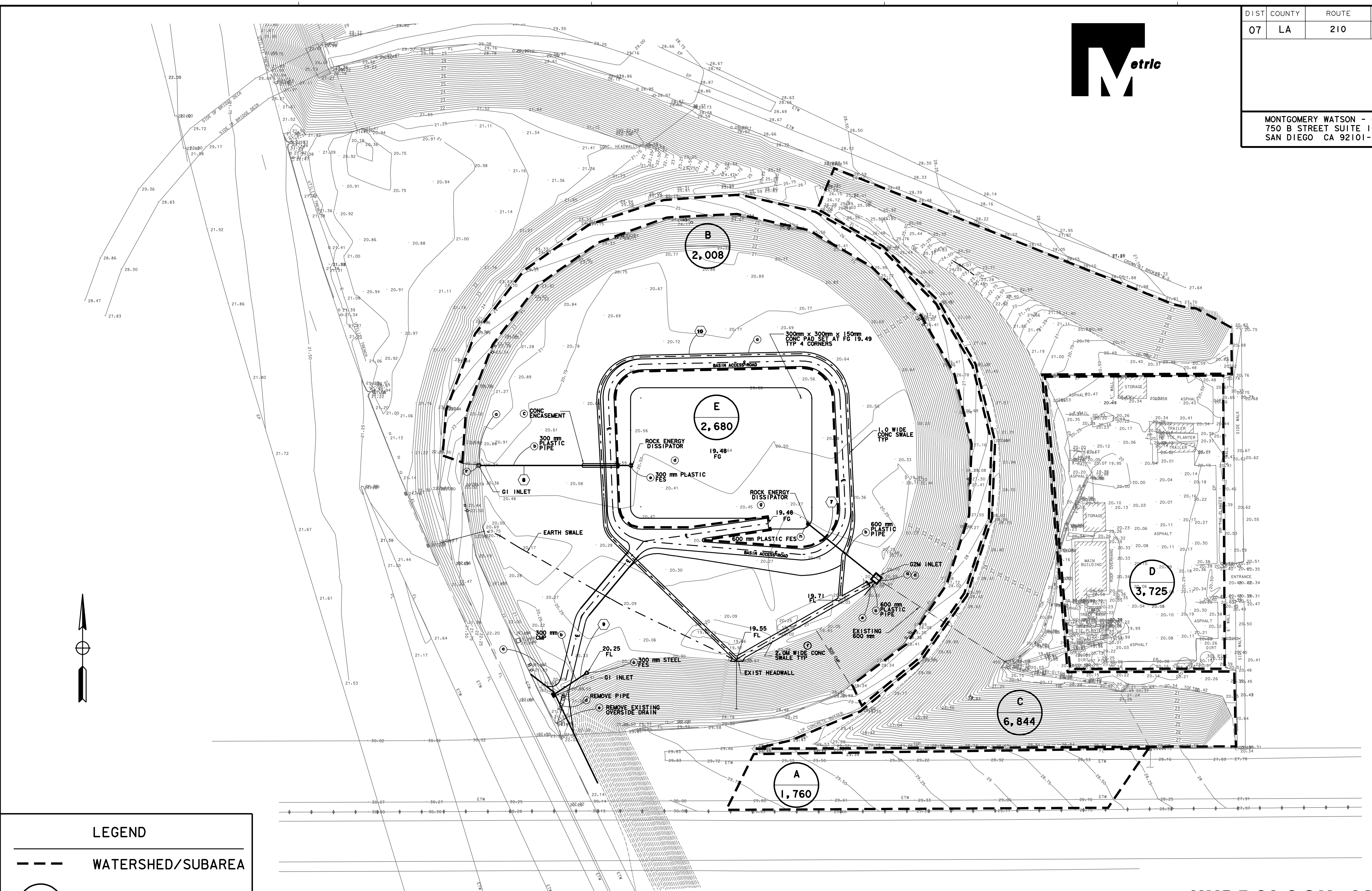
HYDROLOGY MAPS

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	210	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

- WATERSHED/SUBAREA
- AREA DESIGNATION / SUBAREA AREA (M^2) (A / 100)
- DRAINAGE FACILITY

SITE 1 : I-605 / SR-91 SEPARATION

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

HYDROLOGY AMP

SCALE 1:500

H-1

LAST REVISION | DATE PLOTTED => 07-JUN-2000

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

USERNAME => $$$$$$USER$$$$$$

APPENDIX D

HYDROSEED MIX RECOMMENDATIONS

Martha Blane & Associates
Habitat Restoration Consulting

34123
RECEIVED
MAY 14 1998
ROBERT BEIN, WM FROST

May 12, 1998

Bill Whittenberg
RBF & Associates
14725 Alton Parkway
Irvine, CA 92618

Project: Caltrans Storm Water Management - Retrofit Pilot Study

Subject: Planting Recommendations for Bio-Filter Strips

Dear Bill:
In response to your request, enclosed herein is information on candidate plant species for planting within the bio-filter strips. Per our discussions and the background information you provided, the species chosen must perform certain functions and meet specific criteria, as follows:

- Filter suspended solids within runoff from paved areas
- Withstand one-year storm events
- Adapt to climate conditions within Caltrans Districts 7 and 11
- Tolerate periods of both high and low moisture
- Be low-growing
- Require little or no maintenance

Species that meet these criteria are shown on Table 1 (attached), along with information on plant life form, height, origin, beneficial/detrimental characteristics and comments. *Trifolium willdenovii* (tomcat clover), which was recommended previously by others, is also included on Table 1 for the purpose of comparison.

Leguminous plant species were researched because of their ability to add nitrogen to soils. Few legume species are available that meet the criteria listed above, particularly adaptability (i.e., drought tolerance) and low maintenance (most are annuals that may require replanting). To obtain some benefit from the use of nitrogen-fixing species, it is recommended that annual leguminous species be planted initially, but without expectation for natural reseeding.

P.O. Box 4093 • San Marcos, CA 92069 • Phone: (760) 471-1245 • Fax: (760) 471-7671

In order to increase the likelihood of adequate plant cover in the shortest possible time, while fulfilling the criteria above, it is recommended that a mixture of species be planted together. This approach is also beneficial in reducing the potential for damage from diseases and pests that could occur with a one-species, monoculture type planting.

A recommended mixture of species for planting within the bio-filter strips is shown on Table 2 (attached). The table shows the preferred planting method, material application rates for seeds and container plant densities for plants.

The availability of suitable plant species grown as sod was researched. None of the species shown in Table 1 or 2 are grown as sod since there is not an established market for them and most species are not sod forming. It may be possible to request that some species be contract grown (e.g., saltgrass and creeping wildrye) as sod. However, even if a grower agreed to grow sod, there is high risk for failure since it is not a usual practice.

The plant material that can be obtained in a sod-like form is saltgrass. It is grown in flats (±18" x 18") and may be purchased at Tree of Life Nursery in San Juan Capistrano (714.728.0685). However, as shown in Table 2 and described above, planting "plugs" from cut-up flats, along with other species, is recommended.

All seed and plant materials should be ordered well in advance of need to ensure availability. For example, Tree of Life Nursery currently has ±15 flats of saltgrass available. They indicated that it takes about three months (during the warm season) to grow a flat of saltgrass. The needlegrass species are also currently available, but, availability changes on a daily basis.

Per your request, the seed/plant mixture shown on Table 2 was compared to the seed mix presented in Design Directive Memorandum No. 6 (March 11, 1998) to determine which would be more appropriate for general erosion control. Of the two choices, I believe the seed mix shown in Memo. No. 6 would be the better choice. The reason for this is that there are two shrub species included, along with several grass species and a few legumes. The shrubs are the primary difference, and they will add greater diversity in stature, root system, and possibly the longevity of the plantings.

If you need information on other plant mixtures/assemblages, additional lists could be developed. Please contact me with any questions or comments and/or if you would like further assistance.

Sincerely,

Martha Blane

Martha Blane

Attachments: Table 1
Table 2
References and Sources of Information

TABLE 1
PLANT SPECIES SUITABLE FOR BIO-FILTER PLANTINGS

(Page 1 of 2)

Genus species	Common Name	Life Form	Height	Origin/Range
Bromus carinatus	California brome	grass, perennial, short-lived (± 2 years)	18" - 36"	Western US, British Columbia to Central America
Deschampsia caespitosa	Tufted hairgrass	grass, perennial, clumping	12" - 30"	North America
Distichlis spicata	Saltgrass	grass, perennial, rhizome/stolon forming	6" - 20"	North America to South America
Elymus glaucus	Blue wildrye	grass, perennial, clumping	18" - 36"	Alaska to Baja California
Hordeum brachyantherum	Meadow barley	grass, perennial, clumping	12" - 18"	North America to Baja California
Leymus triticoides "Rio"	Creeping wildrye	grass, perennial, creeping rhizomes	18" - 36"+	Western US and Baja California
Lupinus bicolor	Pygmy-leaf lupine	legume, annual	4" - 12"	California deserts, mountains and coastal areas
Nasella lepida	Foothill needlegrass	grass, perennial, clumping	12" - 24"	Northern California to Baja California
Nasella pulchra	Purple needlegrass	grass, perennial, clumping	12" - 24"	Northern California to Baja California
Trifolium willdenovii	Tomcat clover	legume, annual	4" - 16"	Western North America

TABLE 1
(Continued)

(Page 2 of 2)

Genus species	Common Name	Benefits	Detriments	Comments
Bromus carinatus	California brome	Fast-growing, adapted to drought and poor soils.	Short-lived, may be too tall	Often used for soil stabilization and revegetation.
Deschampsia caespitosa	Tufted hairgrass	Grows in dense stands, adapted to moist soils, recovers well from disturbance.	May be too tall, too dense and require too much moisture.	Important range species, widely distributed, sometimes used for erosion control.
Distichlis spicata	Saltgrass	Stout, hardy, adapts to harsh soil conditions (wet or dry) and silt build-up, recovers well from disturbance.	Foliage may turn brown during coldest months.	Spreads by creeping stolons (similar to Bermuda grass in appearance, but not as vigorous), can form a tough mat-like cover.
Elymus glaucus	Blue wildrye	Fast-growing, fast-spreading, good for erosion control.	May be too tall.	Foliage is bluish-green.
Hordeum brachyantherum	Meadow barley	Fast-growing, begins spring growth early, tolerates moist soils.	May be short-lived.	Can provide cover while slower-growing species become established.
Leymus triticoides "Rio"	Creeping wildrye	Tolerates harsh conditions, heavy soils, forms a dense ground cover, long-lived.	May be too tall and too dense.	Stays green late into summer.
Lupinus bicolor	Pygmy-leaf lupine	Nitrogen-fixing, adapts to many soils, germinates early.	Annual, may not reseed if other vegetation is present.	Frequently included in erosion control and revegetation seed mixes.
Nasella lepida	Foothill needlegrass	Adapted to drought and poor/disturbed soils, long-lived, low fuel.	Best in well-drained soils.	Common component of California grasslands; often used for revegetation.
Nasella pulchra	Purple needlegrass	Adapted to drought and poor/disturbed soils, long-lived, low fuel.	Best in clayey soils.	Major component of California grasslands; often used for revegetation.
Trifolium willdenovii	Tomcat clover	Nitrogen-fixing, adapts to heavy soils, germinates early.	Annual, may not reseed.	Seed recently became available for erosion control and revegetation plantings.

TABLE 2
RECOMMENDED SPECIES MIXTURE FOR BIO-FILTER PLANTINGS(1)

Genus species	Common Name	Seed Application Rate Per Acre %Purity/%Germination	Container Plant Spacing and Container Size/Type
Bromus carinatus	California brome	6.0 pounds per acre 95/80	--
Distichlis spicata	Saltgrass	--	12" on-center spacing of "plugs" from cut-up flats
Deschampsia caespitosa	Tufted hairgrass	1.0 pound per acre 80/60	--
Hordeum brachyantherum	Meadow barley	5.0 pounds per acre 90/80	--
Lupinus bicolor	Pygmy-leaf lupine	3.0 pounds per acre 98/80	--
Nasella lepida	Foothill needlegrass	--	12" on-center spacing of groove tubes (2" deep x 3/4" wide)
Nasella pulchra	Purple needlegrass	--	12" on-center spacing of groove tubes (2" deep x 3/4" wide)
Trifolium willdenovii	Tomcat clover	1.5 pounds per acre 95/75	--

1. Seed and container plant recommendations based on which material will provide the most reliable and fastest cover. Some container species are also available as seed.

References and Sources of Information

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A Flora of San Diego County, California. Sweetwater River Press: National City, California.

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APPENDIX E

ENGINEERING COST ESTIMATE

Item	Item Code	Description	Unit of Measure	Est. Qty.	Unit Price	Item Total
1	120090	Construction Area Signs	LS	1	$5,500	$5,500
2	120100	Traffic Control System	LS	1	$50,000	$50,000
3	120165	Channelizer (Surface Mounted)	EA	16	$30	$480
4	129000	Temporary Railing (Type k)	M	115	$28	$3,220
5	129100	Temp Crash Cushion Module	EA	1	$300	$300
6	150771	Remove Asphalt Concrete Dike	M	68	$25	$1,700
7	150801	Remove Overside Drain	EA	1	$1,000	$1,000
8	150806	Remove Pipe	M	12	$70	$840
9	150821	Remove Headwall	EA	1	$600	$600
10	156576	Remove Metal Railing	M	11	$35	$385
11	160101	Clearing and Grubbing	LS	1	$3,800	$3,800
12	190167	Remove Unsuitable Material	M3	1120	$201	$225,120
13	190101	Roadway Excavation	M3	62	$40	$2,480
14	194001	Ditch Excavation	M3	2320	$25	$58,000
15	203045	Seeding	KG	60	$90	$5,400
16	260201	Class 2 Aggregate Base	M3	125	$53	$6,625
17	390103	Asphalt Concrete (Type B)	TONN	45	$100	$4,500
18	394048	Place Asphalt Concrete Dike (Type E)	M	69	$40	$2,760
19	510502	Minor Concrete (Minor Structure)	M3	71	$625	$44,375
20	510504	Minor Concrete (Pipe Encasement)	M3	2	$200	$400
21	520101	Bar Reinforcing Steel	KG	33	$2	$66
22	641101	300 mm Plastic Pipe	M	41	$65	$2,665
23	641136	600 mm Plastic Pipe	M	25	$164	$4,100
24	664010	300 mm CMP Pipe	M	10	$200	$2,000
25	705042	300 mm Steel FES	EA	1	$200	$200
26	705334	300 mm Plastic FES	EA	1	$200	$200
27	705337	600 mm Plastic FES	EA	1	$350	$350
28	720011	ROCK ENERGY DISSIPATER	M3	2	$120	$240
29	721011	RSP (Backing No. 2, Method B)	M3	4	$100	$400
30	729010	Rock Slope Protection Fabric	M2	9	$3	$27
31	750001	Miscellaneous Iron & Steel	KG	444	$3	$1,510
32	832003	Metal Beam Guard Railing (Wood Post)	M	431	$65	$28,015
33	832050	Install Metal Beam Guard Railing (Wood Post)	M	431	$40	$17,240
34	839532	Cable Anchor Assembly (Breakaway, Type B)	EA	2	$550	$1,100
35	839565	Terminal System (SRT)	EA	2	$2,000	$4,000
		Subtotal				**$479,598**
		Contingency	%	10	$47,960	$47,960
		Total				**$527,557**

		STATE FURNISHED MATERIALS AND EXPENSES				
	066105	RESIDENT ENGINEERS OFFICE	MO	2	$2,000	$4,000
	066060	ADDITIONAL TRAFFIC CONTROL	LS	1	$2,000	$2,000
	066070	MAINTAIN TRAFFIC	LS	1	$3,500	$3,500
	066574	ROUTE SHIELDS FOR FUNDING SIGNS	LS	1	$200	$200
		Total				**$9,700**